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ABSTRACT

The student manual in this two-part instructional kit contains basic concepts and specific information needed for understanding anatomy and physiology, with emphasis on those areas of particular interest to health occupations students. The student manual is organized in 10 lessons, each containing objectives, new terms and definitions, technical information illustrated with line drawings, review questions, and suggested activities. The lessons cover the following topics: the organization and general plan of the body, the skeletal system, the muscular system, the digestive system, the blood and cardiovascular system, the respiratory system, the nervous system and special senses, the urinary system, the reproductive system, the endocrine system, and the endocrine glands. A bibliography is included in the manual. The instructor's guide is coordinated with the manual and provides a competencies progress chart, teaching objectives, review questions with answers, unit tests and answers, and suggested activities (either group or individual) with answers. The guide is organized into 10 units corresponding to the 10 lessons of the manual, and line drawing illustrations are also used. (KC)

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Applied Anatomy and Physiology

Student's Manual

By

Catherine Williams

Published by

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(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

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Foreword

This publication, Applied Anatomy and Physiology, is designed for health occupations students. It is to be used along with other curricular materials, such as that which contains the essential elements for the various courses, and for the specific occupations. It contains basic concepts and specific information needed for understanding anatomy and physiology, with emphasis on those areas of particular interest to health occupations students.

The format of this publication lends itself to use in the classroom, but it may also be used for individualized study. Two publications are offered—a student's manual and an instructor's guide. The student's manual contains objectives and information. The instructor's guide provides a competencies progress chart, teaching objectives, unit tests and answers, and suggested activities with answers. The suggested activities in particular should be used at the discretion of the instructor, as a group activity or as an individual activity.

Although both publications are copyrighted, the instructor should feel free to reproduce the suggested activities and unit tests. If you prefer, these same sheets can be ordered separately from Extension Instruction and Materials Center, the University of Texas at Austin, P. O. Box 7218, Austin, Texas 78713-7218.

Every effort has been made to produce a publication that addresses the unique needs of our current student population. Students with limited English proficiency (LEP) as well as handicapped, educationally disadvantaged, and nontraditional students may require modification of the material in this publication. The professional staff of EIMC will gladly work with any instructor having these students to show how the instructional material can be adapted for specific individualized instruction. Consult local, state, and federal agencies that offer assistance and guidance and that can provide sound recommendations for productive classroom management.

Kathryn R. Allen, Ph.D.
Director, Extension Instruction
and Materials Center

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Catherine Williams
Curriculum Specialist

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Notes for the Student

Health occupations students soon realize that they have a special interest in and a need to know anatomy and physiology. This is required information for any area of health care. This publication is designed for use as an introduction to anatomy and physiology. Most students will need to continue this study in greater depth, or with special emphasis on the areas in which they are most interested.

In using this manual, note the objectives at the beginning of each unit. These tell you what you will have an opportunity to learn. The new terms listed at the beginning of each narrative will be used in the lesson. The definitions are meant to serve as a "mini-dictionary" to save you time in finding the meaning of unfamiliar words and to define them in the context in which they are used.

The narrative and illustrations provide practical information and explanations. The review questions are planned to encourage you to review the most important areas, or those most difficult to understand.

The suggested activities are exactly that. They are designed to help reinforce your learning and understanding of the lesson. Some of these suggestions require work that might be done in classes other than Health Occupations Education. Some experiments might be done in chemistry or biology laboratories. Laboratory equipment and models from other departments will be useful for demonstrations. Research papers might be done in English classes under the supervision of English instructors. Some of the topics suggested for research have social significance and thus could be the basis for discussion, debate, or a written project for social studies.

Health Occupations Education can well be a subject in which academic skills and vocational skills can blend together to help you be a better educated person.

1

The Organization and General Plan of the Body

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the organization and general plan of the body;*
2. *identify studies related to anatomy and physiology;*
3. *list and describe the levels of structural organization of the body;*
4. *define anabolism and catabolism;*
5. *name, locate, and give the function of cell parts;*
6. *describe special structures that modify cells for a specific role;*
7. *name four types of tissue, and give the general function of each;*
8. *give examples of organs;*
9. *name the nine major systems in the human body;*
10. *define directional terms used to locate body parts;*
11. *name the four quadrants of the abdominopelvic cavity;*
12. *name the nine regions of the abdominopelvic cavity when the area is divided;*
13. *locate body cavities, and tell what organs are contained in each; and*
14. *name and locate three body planes.*

New Terms and Definitions

anatomic position—standing erect with arms at the sides and palms forward.

cilia—hairlike processes extending from the body of a cell.

cranial—pertaining to the skull or cranium.

cristae—partitions formed by the folds of the inner membrane of the mitochondria.

epigastrium—region over the pit of the stomach.

flagellum—single whiplike extension from the main body of some cells; used in locomotion.

genetic—pertaining to heredity.

hemopoietic—pertaining to the production and development of blood cells.

hypochondrium—the portion of the abdomen beneath the lower ribs on each side of the epigastrium.

inguinal—region of the groin.

lumbar—region of the back between the ribs and the pelvic girdle.

metabolism—the sum of the chemical processes of the body.

microvilli—microscopic projections from some cells that increase surface area; found in the lining of the small intestine.

mitosis—type of cell division.

organelles—living particles contained in the cytoplasm of the cell (little organs).

permeable—allowing the passage of substances, as through a membrane.

phagocytosis—the engulfing and destruction of foreign particles or bacteria by some cells.

pinocytosis—the absorption of liquids by some cells.

pleural—pertains to the membranes that cover the lungs and line the chest wall.

cytology—the study of cells.

endocrinology—the study of endocrine glands.

environmental health—the study of factors in the environment that affect the health and well-being of people.

genetics—the study of heredity.

hematology—the study of the blood.

histology—the study of the microscopic structure of tissue.

kinesiology—the study of muscles and muscular movement.

nutrition—the taking in and use of food by the body.

osteology—the study of the structure and function of the bones.

pathology—the study of disease conditions.

Fig. 1. Studies related to anatomy and physiology

umbilicus—navel.
vesicle—small sac or bladder containing fluid; a blister.

Anatomy is the study of the structure of the body. Physiology is the study of the function of the body. The study of anatomy includes the names and locations of the various body parts and their relation to each other. Physiology treats the functions of the body parts and how they all work together to perform the complex activities of a living body. When you study the structure of the stomach, that's anatomy; when you study the process of digestion, that's physiology.

In studying anatomy and physiology, you will develop an appreciation and understanding of the efficiency and organization of the body. You will also learn that, in spite of **all** the information available, many questions have yet to be answered, and much more investigation has yet to be done in the study of the human body.

No branch of science is independent of other areas of knowledge. Thus, anatomy and physiology must include some basic biology, chemistry, and physics. Genetics, nutrition, and environmental health are also areas closely related to the study of anatomy and physiology. Figure 1 lists some studies that are included in anatomy and physiology.

All living things must have an organized structure, and the human body is no exception. The lowest organizational level is chemical. Atoms combine to form molecules of chemical compounds needed to build and maintain the body. These chemical compounds form cells, the next level of organization. Cells form tissues. Various tissues that together perform a function form an organ. The organization of different organs to perform a complex function is a system. Finally, all systems combined form a complete organism (fig. 2).

The **cell** is the unit of structure and function of all living things. The study of cells is cytology. Although the body is made up of countless numbers of different cells, they all have the same basic parts and carry out the same life processes. In the same way, there are billions of people in the world, each one different, yet each body carries on the same basic biological processes.

Living matter is called protoplasm. The protoplasm of which cells are made is called **cytoplasm.** Cells, like all living organisms, carry on life processes or metabolism. Some metabolic activities are building activities, called **anabolism,** in which the cell combines simple compounds to produce complex compounds. Examples of anabolism are growth, reproduction, and biosynthesis. **Catabolism** is the metabolic process in which complex compounds are broken down into simpler substances, usually with the release of energy. Examples of catabolism are digestion and respiration. Anabolism and catabolism must remain balanced to preserve the life of the cell.

Cells vary a great deal in size and shape, but most are microscopic. It is only with the electron microscope that the inner structures can be studied. Most are modified for their specific function. Figure 3 is a diagram showing the parts found in most cells.

Cells are covered by a protective membrane called the plasma membrane, or simply the **cell membrane.** It is composed primarily of protein and lipid molecules. It is a very important part of the cell in that it is selectively permeable. This means that it permits needed molecules to enter the cell by osmosis and excludes harmful molecules. The cell membrane also contains proteins on its surface that identify the cells of that particular individual. Other surface proteins act as communicators. Hormones on the cell membrane transmit messages while other molecules receive chemical messages. Areas of the plasma membrane of white blood cells are modified to act as antibodies. This means they can react with harmful substances such as invading bacteria and destroy them. So, in summary the plasma membrane determines the entry of molecules into the cell by osmosis, identifies the cells of each individual, sends and receives messages, and (in white blood cells) acts as an antibody.

The **cytoplasm** is that part of the cell between the plasma membrane and the nucleus. It is a sticky liquid in which the nucleus and organelles are suspended.

Organelles (little organs) are living particles contained in the cytoplasm of the cell. They each perform a function essential for the maintenance, growth, control, and reproduction of the cell. The endoplas-

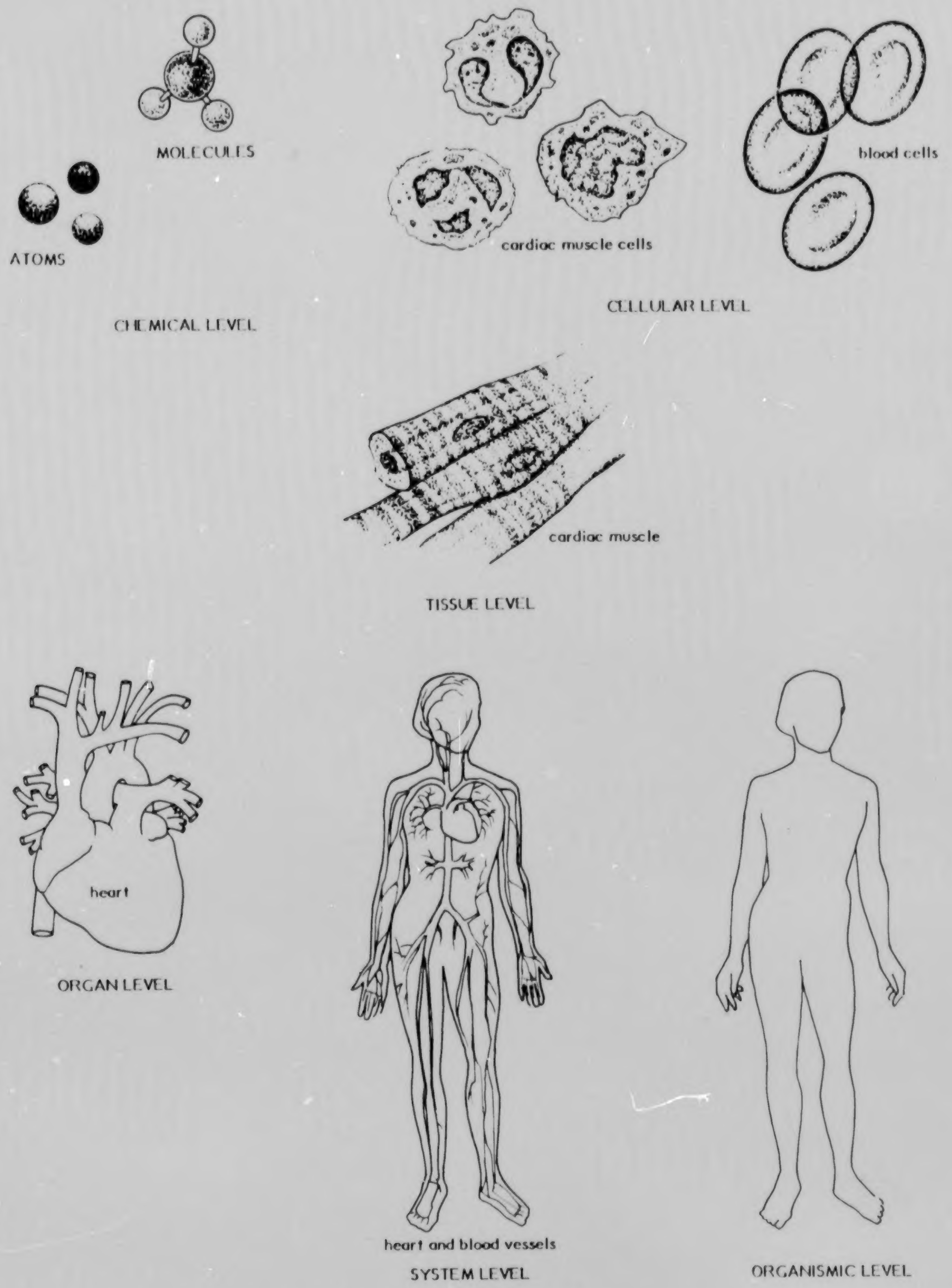
MOLECULES
ATOMS
CHEMICAL LEVEL
cardiac muscle cells
blood cells
CELLULAR LEVEL
cardiac muscle
TISSUE LEVEL
heart
ORGAN LEVEL
heart and blood vessels
SYSTEM LEVEL
ORGANISMIC LEVEL

Fig. 2. Structural levels of organization

mic reticulum, the Golgi apparatus, mitochondria, lysosomes, and centrosomes are all organelles. The cell may also contain nonliving particles or inclusion bodies. These include pigments, secretory granules, vacuoles, and oil droplets.

The **endoplasmic reticulum** is a system of interconnected channels that extend throughout the cytoplasm. They extend from the cytoplasmic membrane to the nuclear membrane. They have been likened to a miniature circulatory system for the cell since they provide a network for the delivery of materials throughout the cytoplasm of the cell.

The functions of the endoplasmic reticulum are to provide the surface area where chemical reactions (protein synthesis) can take place, to provide for the transport of materials within the cell, and to provide storage for molecules synthesized by the cell.

The channels of the endoplasmic reticulum resemble a system of flat, curving sacs arranged in parallel rows. Attached to the endoplasmic reticulum are extremely small, submicroscopic structures called ribosomes. These tiny bodies contain RNA (ribonucleic acid), which controls protein synthesis in all cells. Thus, the function of the ribosomes is protein synthesis. These little bodies synthesize the enzymes needed to bring about the reactions that enable the cell to grow and maintain itself. (Enzymes are complex protein molecules.) The protein molecules produced then move through the network formed by the endoplasmic reticulum to the Golgi apparatus.

The Golgi apparatus (named for Dr. Camillo Golgi) consists of flattened sacs or channels that appear to be stacked one on the other. They are located in the cytoplasm near the nucleus of the cell. The function of the Golgi is to synthesize large carbohydrate molecules and combine them with protein molecules from the endoplasmic reticulum to form glycoproteins. As these molecules form, they accumulate in the channels of the Golgi apparatus and form vesicles. The vesicles thus formed pinch off from the Golgi apparatus and move through the cytoplasm to the cell surface where they rupture and liberate the glycoproteins. It is believed that some lipids or fats are also produced by the Golgi apparatus.

Energy is released in the cell in the **mitochondria.** These are small bodies in the cytoplasm visible under an ordinary light microscope. However, an electron microscope is necessary to study their inner structures. A mitochondrion is covered by a double membrane and is filled with fluid. The inner membrane folds inward to form "partitions" called cristae (fig. 4). This infolding increases the surface area greatly. The enzymes that bring about the release of energy are located on the cristae. The mitochondria contain the enzymes necessary for making adenosine triphosphate, or ATP, a compound that stores energy needed for body activities.

Lysosomes are another type of organelle found in the cytoplasm of the cell. They are tiny bubblelike structures enclosed in a membrane. Each lysosome contains powerful digestive enzymes. Their function is to digest and destroy any particles or molecules that have invaded the cell. In white blood cells, it is the enzymes contained in lysosomes that destroy and digest invading bacteria. These enzymes digest the other cell components when a cell dies.

The **centrosomes** are dense areas of cytoplasm near the nucleus of the cell. These are a pair of cylinders that lie at right angles to each other. No one knows why they are in this position. The centrosomes are important in cell division (mitosis), but their role is not well understood. Mature nerve cells lack centrosomes, and are apparently unable to reproduce. Injured or destroyed nerve cells are not replaced. This reinforces the concept of a role in cell reproduction for centrosomes.

The **nucleus** is a dense, ball-shaped structure, usually in the center of the cell. It controls and regulates the metabolic activities and reproduction (mitosis) of the cell. It is surrounded by a double membrane, which has openings that connect with the canals of the endoplasmic reticulum. In this way materials may move between the nucleus and the cytoplasm. The nucleus is filled with a gel-like substance called nucleoplasm. Also contained in the nucleus are small, dense bodies, the nucleoli. These structures are composed primarily of RNA (ribonucleic acid). It is thought that they synthesize the RNA in the ribosomes.

The nucleus also contains chromatin granules, which are important in the trans-

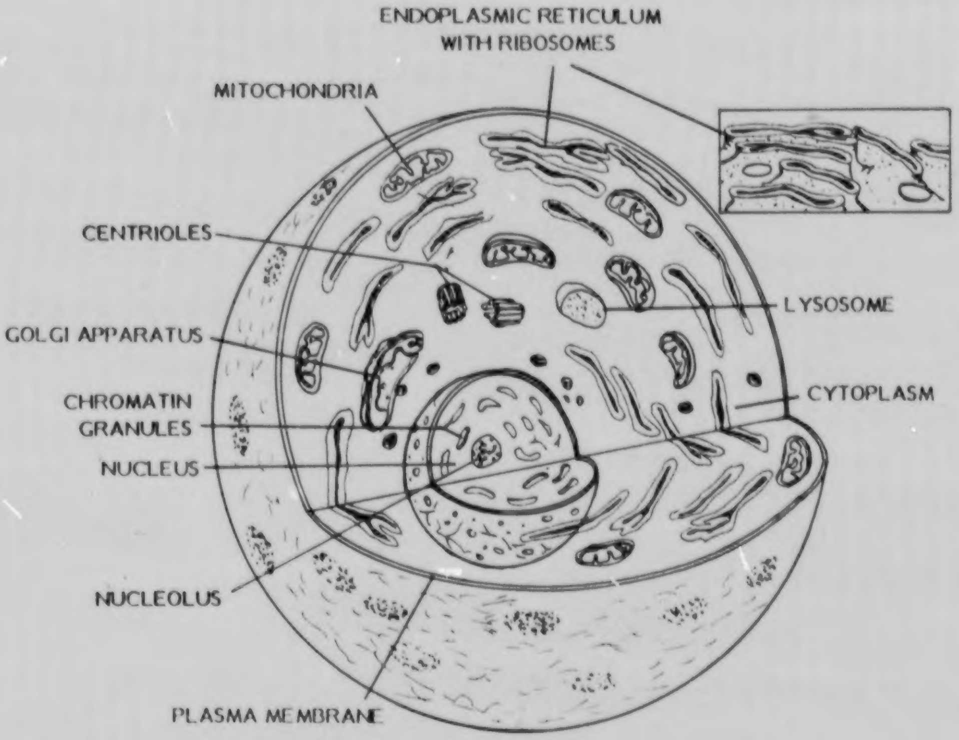
ENDOPLASMIC RETICULUM
WITH RIBOSOMES
MITOCHONDRIA
CENTRIOLES
LYSOSOME
GOLGI APPARATUS
CHROMATIN
GRANULES
CYTOPLASM
NUCLEUS
NUCLEOLUS
PLASMA MEMBRANE

Fig. 3. The cell

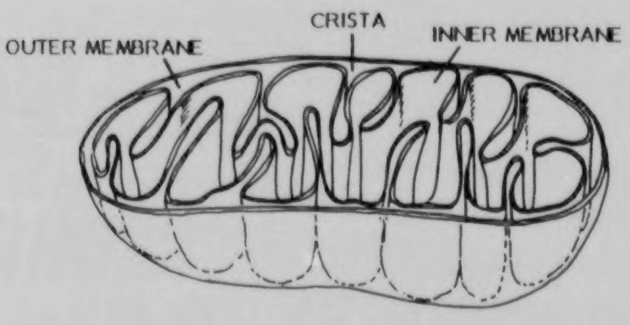
CRISTA
OUTER MEMBRANE
INNER MEMBRANE

Fig. 4. Mitochondrion showing cristae

mission of hereditary traits in mitotic cell division. Chromatin contains protein and the nucleoprotein deoxyribonucleic acid (DNA). DNA molecules are the substance that determines hereditary traits. In mitotic cell division, DNA replicates, and each daughter cell has exactly the same DNA components. (Mitotic cell division should be studied for clarification of the process.)

In most cells, the nucleus is essential for the survival of the cell; enucleated cells die. However, mature red blood cells do not have a nucleus. Rather, their activity is controlled by their environment. They do not reproduce by the usual mitotic process. Instead, they are produced in the bones.

Cells vary a great deal and are modified for their specific function and location. Some have special structures that adapt them to their role. An example is a **flagellum**, which is a single, whiplike projection that extends from the surface of the cell. Its function is to propel the cell through a liquid medium. Flagella are found on the spermatozoa, or male sex cells.

Cilia are short hairlike projections extending from the surface of some epithelial cells. They are an extension of the cytoplasm and cytoplasmic membrane of the cell. They are found in the mucous membrane of the upper respiratory tract. They maintain a rhythmic, beating motion that is coordinated to move fluid across the surface of the cells. In this way the cilia propel the mucus and small foreign particles upward into the respiratory tract so they can be eliminated.

A final type of projection from the cell surface is the **villi** found on the epithelial cells in the small intestine. There are many villi on each cell. They provide great surface area for the absorption of digested food. The villi are also extensions of the cytoplasm and cytoplasmic membrane.

Cells have many functions related to their survival and reproduction. Some cells are capable of engulfing solid objects or bacteria. The cell membrane flows around the object, and the membrane folds inward, engulfing the particle and forming a sac. Enzymes digest and destroy the particle, and indigestible particles are pushed from the cell. This process is called **phagocytosis.** An important example of phagocytosis is the destruction of bacteria by white blood cells.

Pinocytosis is similar to phagocytosis, but the engulfed particle is liquid rather than solid. Again, the cell membrane enfolds the liquid droplet in the cell, then releases the liquid into the cytoplasm of the cell.

The human body is made of countless cells of many different kinds, which function together (fig. 5). A group of like cells makes up a tissue. There are four kinds of tissue—epithelial, connective, muscle, and nerve tissue. The main functions of **epithelial tissue** are protection, absorption, and secretion. It is found most often as a lining or cover for organs and cavities and in the formation of glands.

Connective tissue has relatively few cells. The bulk of the tissue consists of an intercellular matrix. It provides support, forms blood cells, and connects other tissues. Examples of connective tissue are varied, and some connective tissue is not "connected." Blood is classified as connective tissue even though the individual blood cells are not joined together. Bone, cartilage, fat, and hemopoietic tissue are other examples of connective tissue.

The muscles of the body are formed of **muscle tissue.** There are three types of muscle tissue—skeletal, visceral (smooth), and cardiac. The function of all muscle tissue is to contract. Contraction is followed by relaxation. Skeletal muscles are attached to bones, and their action makes skeletal movement possible. Smooth muscles are those that make possible the functioning of the internal or visceral organs, such as the stomach, intestinal tract, respiratory organs, or the muscles contained in blood vessels. The heart is made of cardiac muscle, and its rhythmic contraction sends the blood throughout the body.

Nerve tissue, the fourth type of tissue, is made up of neurons or nerve cells. Its function is to transmit information and nerve impulses throughout the entire body and to control body activity.

Organs are formed from various tissues that together perform a function. For example, connective, muscle, epithelial, and nerve tissue all combine to form the stomach.

A **system** is an organization of different organs arranged to perform a complex func-

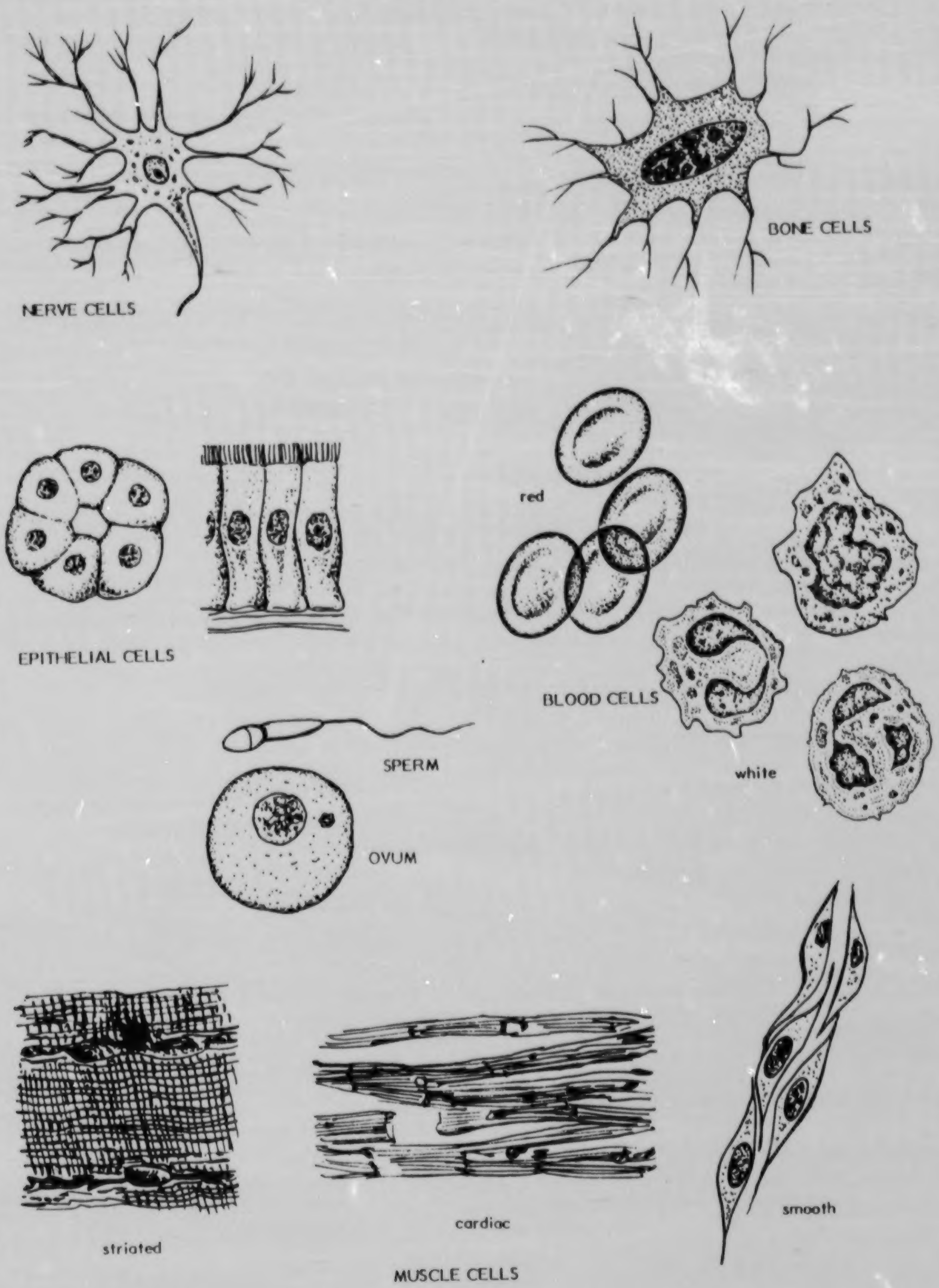
NERVE CELLS
BONE CELLS
EPITHELIAL CELLS
red
BLOOD CELLS
white
SPERM
OVUM
striated
cardiac
smooth
MUSCLE CELLS

Fig. 5. Types of cells

superior—toward the head, upper; above.

inferior—toward the feet; lower, below.

anterior—front; in front of.

posterior—back; in back of.

medial—toward the midline.

lateral—away from the midline; toward the side of.

proximal—toward or near the trunk of the body; near the point of origin.

distal—away from the point of origin.

superficial—confined to the surface; opposed to deep.

parietal—pertaining to the wall of a cavity.

visceral—pertaining to organs inside the body cavity, especially abdominal organs.

Fig. 6. Terms to locate body parts

tion. For example, all of the organs such as the stomach, small intestine, large intestine, and others make up the digestive system. There are nine major systems in the human body—skeletal, muscular, digestive, circulatory, respiratory, nervous, urinary, reproductive, and endocrine. All systems combined form an organism—a whole, living thing.

To study the human body, you must understand not only its organization from cell to organism, but also the specific terms that indicate directions in locating body parts. North, south, east, and west just aren't specific enough. The directional terms shown in figure 6 are essential to know.

Another device for study of the location of body parts is to arbitrarily divide the abdominopelvic cavity into areas. The name of the area supplies a reference point. For example, one method is to divide the area into four equal parts by drawing imaginary lines both horizontally and vertically through the umbilicus. The quadrants thus delineated are shown in figure 7:

right upper quadrant	RUQ
left upper quadrant	LUQ
right lower quadrant	RLQ
left lower quadrant	LLQ

Another method for naming body regions divides the abdominopelvic area into nine regions by drawing four imaginary lines, two vertical and two horizontal. The top horizontal line is beneath the lower ribs; the bottom horizontal line is just below the iliac crests. The vertical lines are drawn on each side through the center of the nipples (fig. 8). Starting with the upper left division, the nine regions are the right hypochondriac, epigastric, left hypochondriac, right lumbar, umbilical, left lumbar, right inguinal, hypogastric, and left inguinal. These terms will have more significance as we continue the study of anatomy.

The body also has several cavities in which organs are housed (fig. 9). The two large cavities are the dorsal and ventral body cavities, which are each divided. The **dorsal cavity** is divided into the cranial cavity in the skull (which houses the brain) and the spinal cavity in the vertebral column (which houses the spinal cord).

The **ventral cavity** is much larger and is divided by the diaphragm into the thoracic and abdominopelvic cavities. The thoracic cavity is divided into two pleural cavities, each of which contains a lung. Also present in the thoracic cavity is the pericardial cavity, which encloses the heart.

The abdominopelvic cavity is divided arbitrarily into the abdominal and pelvic cavities. The abdominal cavity contains the stomach, spleen, liver, gallbladder, pancreas, small intestine, part of the large intestine, kidneys, and ureters.

The pelvic cavity contains the urinary bladder, sigmoid colon, rectum, and internal male or female reproductive organs. It lies in the lower third of the abdominopelvic cavity.

In discussing body directions and areas, it is necessary to determine a reference point. The anatomic position is such a point. In the **anatomic position**, the body is erect and facing the observer. The arms are at the sides, palms turned forward.

In discussing body directions and regions, we must also consider body planes. A plane in this context means an imaginary flat surface. These terms are particularly important in anatomic directions. If the body is divided into equal right and left sides by a vertical line, this is a **median** plane. The **frontal** plane divides the body evenly into anterior and posterior segments, by a vertical line (fig. 10). The **transverse** plane is a horizontal line that divides the body into superior and inferior segments.

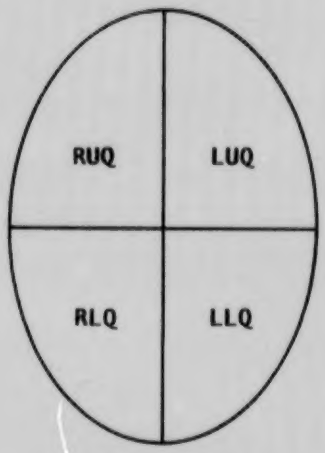
RUQ
LUQ
RLQ
LLQ

Fig. 7. *Division of abdominopelvic region into quadrants*

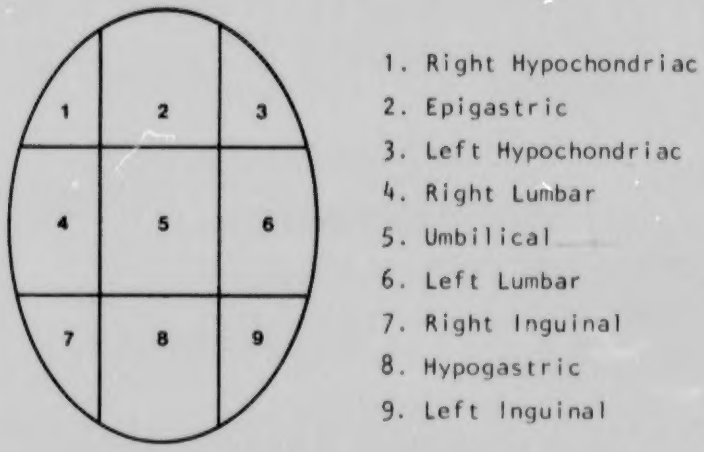
1
2
3
4
5
6
7
8
9
1. Right Hypochondriac
2. Epigastric
3. Left Hypochondriac
4. Right Lumbar
5. Umbilical
6. Left Lumbar
7. Right Inguinal
8. Hypogastric
9. Left Inguinal

Fig. 8. *Division of abdominopelvic area into nine regions*

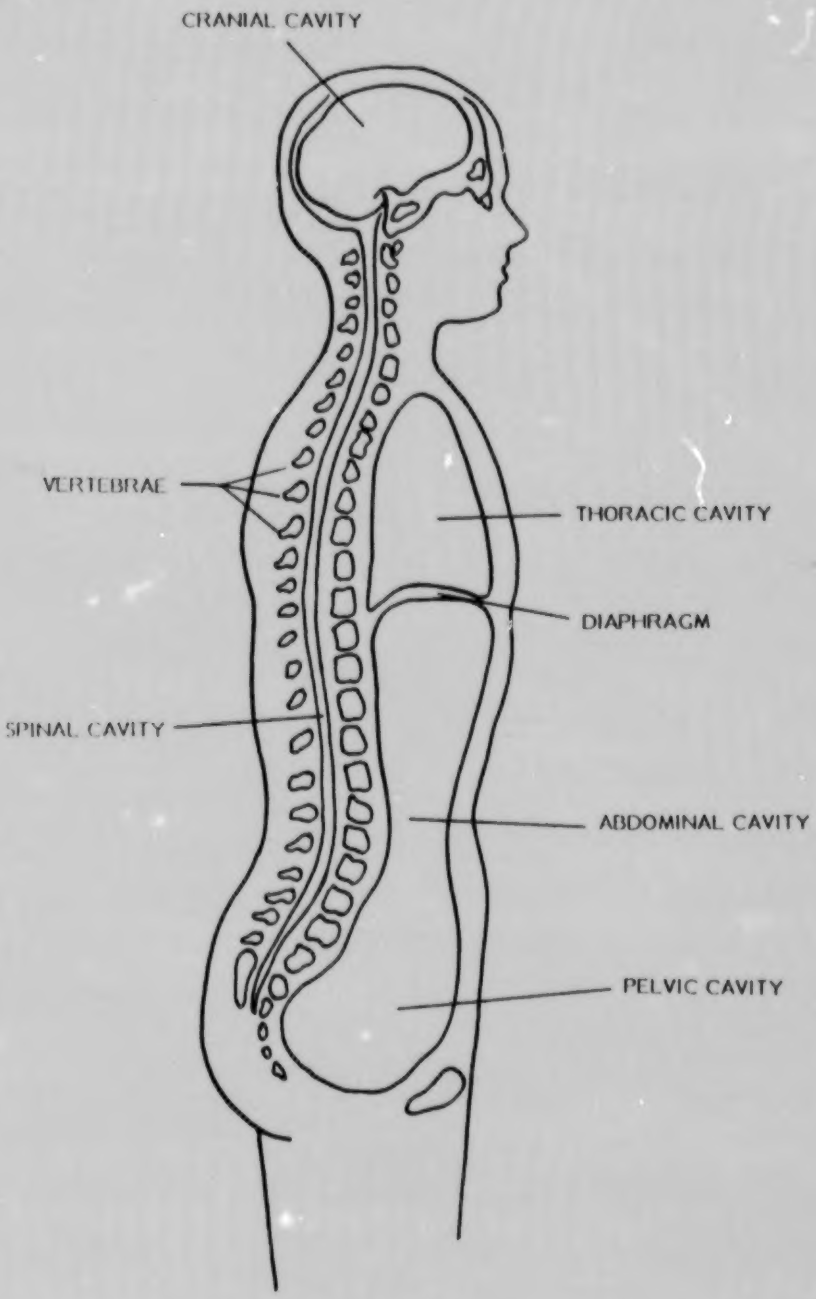
CRANIAL CAVITY
VERTEBRAE
THORACIC CAVITY
DIAPHRAGM
SPINAL CAVITY
ABDOMINAL CAVITY
PELVIC CAVITY

Fig. 9. Body cavities

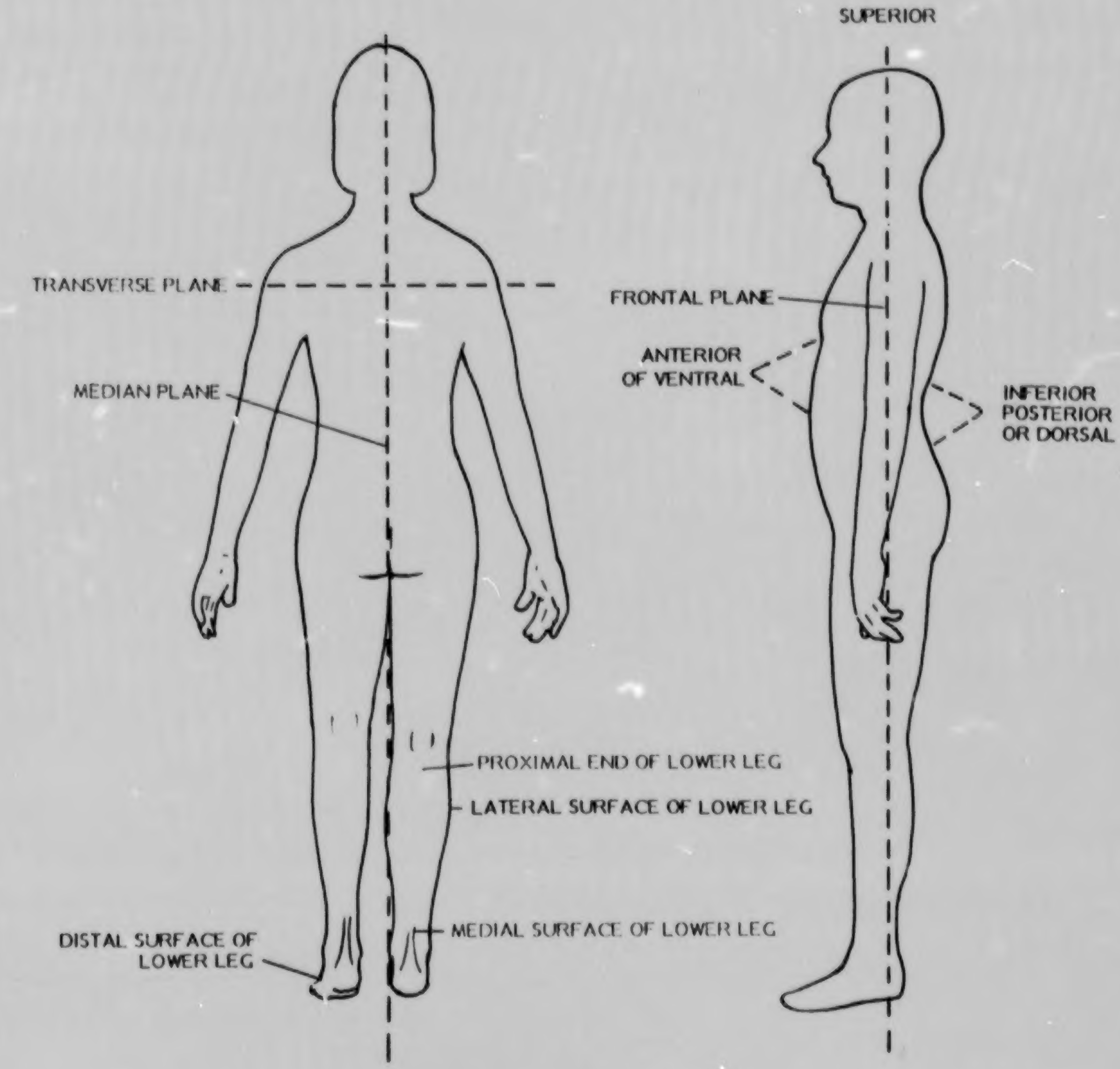
SUPERIOR
TRANSVERSE PLANE
FRONTAL PLANE
ANTERIOR
OF VENTRAL
MEDIAN PLANE
INFERIOR
POSTERIOR
OR DORSAL
PROXIMAL END OF LOWER LEG
LATERAL SURFACE OF LOWER LEG
DISTAL SURFACE OF
LOWER LEG
MEDIAL SURFACE OF LOWER LEG

Fig. 10. Median plane (left) and frontal plane (right)

2

The Skeletal System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the skeletal system;*
2. *give the functions of the skeletal system;*
3. *describe two types of bone tissue;*
4. *name, locate, and give the function of each part of a long bone;*
5. *give the materials required for building bone;*
6. *describe the different types of bones;*
7. *identify bones in the axial and appendicular skeletons;*
8. *identify specific bones on a model or diagram;*
9. *tell about the role of cartilage in the skeletal system;*
10. *name and describe five types of bone fractures;*
11. *describe six types of joints;*
12. *explain types of movement at joints; and;*
13. *describe common bone diseases.*

New Terms and Definitions

amphiarthrosis—joint that is slightly movable.

articulation—point at which two bones come together; a joint.

bursa—sac or cavity found between bones in joints or between tendons and bones.

cancellous bone tissue—type of bone tissue characterized by many open spaces among bone processes; has a spongelike appearance.

cartilage—specialized connective tissue made up of cells (chondrocytes) embedded in a collagenous matrix; tough, flexible material that makes up part of the skeleton.

compact bone tissue—type of bone tissue that is hard, dense, and without open spaces.

diaphysis—long, main portion or shaft of bone.

diarthrosis—joint that is freely movable; a hinged joint.

endosteum—lining of the medullary canal of bones; made primarily of osteoblasts and osteoclasts.

epiphysis—the ends of long bones, covered with articular cartilage at the joints.

Haversian canals—channels that run longitudinally throughout compact bone.

ligament—connective tissue that binds bones together at the joints.

matrix—basic substance from which a thing is made or develops; intercellular material of a tissue.

medullary cavity—the hollow shaft of a long bone.

nutrient—food substance that supplies the body with elements used in metabolism; the usable part of food.

obese—extremely fat.

osteoblast—bone cells that form bone.

osteoclast—bone cells that destroy bone tissue.

osteocyte—bone cell.

periosteum—white, fibrous, protective covering on the outer surface of bone.

sesamoid—small rounded bones found next to joints that help eliminate friction and increase efficiency in hinge joints.

synarthrosis—an immovable joint.

tendon—connective tissue that attaches muscles to bones.

trauma—injury or wound caused by external force or violence.

Volkmann's canals—channels that run horizontally through compact bone; they extend from the periosteum to the Haversian canals.

Functions of the Skeletal System

The skeleton is made up of bones and cartilage. It has five general functions. First, it **supports** the body and gives it form and shape. Without bones, the human body would be a shapeless mass. Second, the bones provide sites for muscle attachment and thus make possible **movement** or locomotion. Third, the bones provide **protection** of body parts. All delicate parts such as the brain, spinal cord, heart, and lungs could be easily damaged without the protection of the bones. The **production of blood cells** is a fourth function of the skeletal system. Although some lymphocytes and monocytes, which are types of white blood cells, are produced in lymphoid tissue, red blood cells, platelets, white blood cells called granulocytes, and some lymphocytes and monocytes are all produced in bone marrow. Finally, bones **store fat and mineral salts,** especially of calcium and phosphorus.

Structure of the Skeletal System

Bone (osseous tissue) is a type of connective tissue. This is the hardest connective tissue in the body. In Unit 1, connective tissue was described as having few cells, with the bulk of the tissue consisting of an intercellular matrix. In bone tissue, this matrix contains many collagen fibers impregnated with compounds of calcium and phosphorus. These minerals give bone its characteristic hardness and actually account for about two-thirds of its weight.

There are two types of bone tissue—cancellous and compact. **Cancellous bone tissue** has many open spaces and thus a spongy appearance. Blood vessels from the outer bone cover (periosteum) infiltrate the spaces in cancellous bone tissue and provide food and oxygen and remove waste products of metabolism. In spite of its solid appearance and strong construction, bone tissue is living and has the same metabolic needs as any other tissue. Cancellous bone contains red marrow which produces blood cells.

Compact bone tissue is dense. Microscopically, it appears as concentric circles. These circles are actually bony plates, each of which is arranged concentrically around tiny channels or canals, called **Haversian canals.** These channels run longitudinally throughout the compact bone. Each canal contains blood vessels and nerves and carries nutrients to the bone cells. There are also horizontal channels through compact bone called Volkmann's canals. These microscopic channels extend from the periosteum to the Haversian canals and to the inner or medullary cavity of bones. They too contain minute blood vessels and nerves. Thus, the Haversian canals and Volkmann's canals provide a means of transportation for food, oxygen, and metabolic wastes, and a nerve supply throughout bone tissue.

Bone is living tissue even though it may seem lifeless. Bone cells, or osteocytes, are contained in the small spaces of the Haversian canals. They are of two types, osteoblasts and osteoclasts. **Osteoblasts** actually form collagen fibers using calcium and phosphorus. They are found in the periosteum and endosteum. **Osteoclasts** are bone cells that destroy bone tissue. A balance between cell building with attendant storage of calcium, and cell destruction with liberation of calcium is maintained. The blood constantly supplies calcium for bone building and retrieves calcium from bone destruction to return it to the circulating blood. It is possible for calcium to be returned to the blood in quantities that leave the bone weakened and more apt to break.

The body requires various regulatory substances to build osseous tissue. Compounds of calcium and phosphorus are essential. Also, vitamins D, C, and A are required for the absorption of these mineral compounds. A hormone produced by the parathyroid glands called parathormone regulates the levels of calcium and phosphorus in the blood. Deficiencies of any of these minerals, vitamins, and hormones may result in serious skeletal disorders.

To discuss the overall gross structure of bone, a long bone is usually used as an example (fig. 1). The long, main portion or shaft of the bone is called the **diaphysis**. It is made primarily of compact bone and is a hollow cylinder in shape. This shape provides maximum strength and support with minimum weight.

The ends of long bones are called **epiphyses** (singular is epiphysis). Their rounded or bulbous shape provides maximum space for muscle attachment. They are made of cancellous bone and thus have a spongy appearance. This spongy characteristic makes the epiphyses more able to withstand shocks and jolts without harm. Red bone marrow is contained in the spongy cancellous bone.

The **periosteum** is a white, fibrous protective covering on the outer surface of bone. It is well supplied with blood vessels, nerves, and lymph vessels. These vessels connect with the Haversian and Volkmann's canals within bone. The periosteum is essential for bone growth and maintenance.

The hollow shaft of long bones is called the **medullary cavity**. This cavity contains yellow bone marrow. The lining of the medullary cavity is the **endosteum**, and it is made up primarily of osteoblasts with a few osteoclasts.

Articular cartilage covers the epiphyses in those areas where the ends of separate bones meet to form a joint. This cartilage provides protection for the bone ends and helps to ensure smooth movement of the joints.

The human skeleton is made up of over two hundred bones, each modified for its specific function. They can be divided into broad groups according to their size and shape:

- **Long bones** include the bones of the upper and lower arm, upper and lower leg, and fingers and toes. They are composed primarily of compact bone, although cancellous bone is found in the epiphyses.
- **Short bones** include the bones of the wrist and ankle. These are not just miniature long bones. They are made of cancellous bone covered with compact bone. They provide strength.
- **Flat bones** consist of an inner portion of cancellous bone with an outer layer of compact bone. Because of the broad, flat shape of these bones, they provide protection for vulnerable body parts and large areas for muscle attachment. Examples are the ribs, the scapulae, and some of the bones of the skull.
- **Irregular bones** have unusual and specialized shapes. Their overall function is articulation. Their irregular shape makes it possible for them to fit smoothly to form joints. Examples are the vertebrae of the spinal column, the bones of the inner ear, and some of the facial bones. They are made of inner cancellous bone covered with an outer layer of compact bone.
- **Sesamoid bones** are small, rounded bones found next to joints. These are covered with cartilage or ligaments. They help eliminate friction in joints and increase the efficiency of motion in hinge joints. The patella (kneecap) is an example.

Axial and Appendicular Skeletons

For ease of discussion, the bones are usually grouped into the axial and appendicular skeletons (fig. 2). The **axial skeleton** refers to bones arranged around the long axis of the body. It includes the bones of the skull, the vertebral column, the ribs, the sternum, the three small bones of the ear, and the hyoid bone.

The bones of the skull include those of the cranium, which enclose and protect the brain, and the facial bones, such as those of the nose, cheeks, and jaws. There are eight cranial bones and fourteen facial bones. The cranial bones include the frontal, occipital, parietal, temporal, sphenoid, and ethmoid bones (fig. 3). These bones form immovable or synarthrotic joints. The areas of juxtaposition are irregular, yet fit together like the irregular pieces of a puzzle. The surfaces are further united by a thin, fibrous membrane. Such structure gives great protection from injury. In infants, space between the cranial bones provides room for growth of the skull. The spaces are called fontanels and are protected from injury by the fibrous membrane. Bone formation continues as the child grows and the fontanels close.

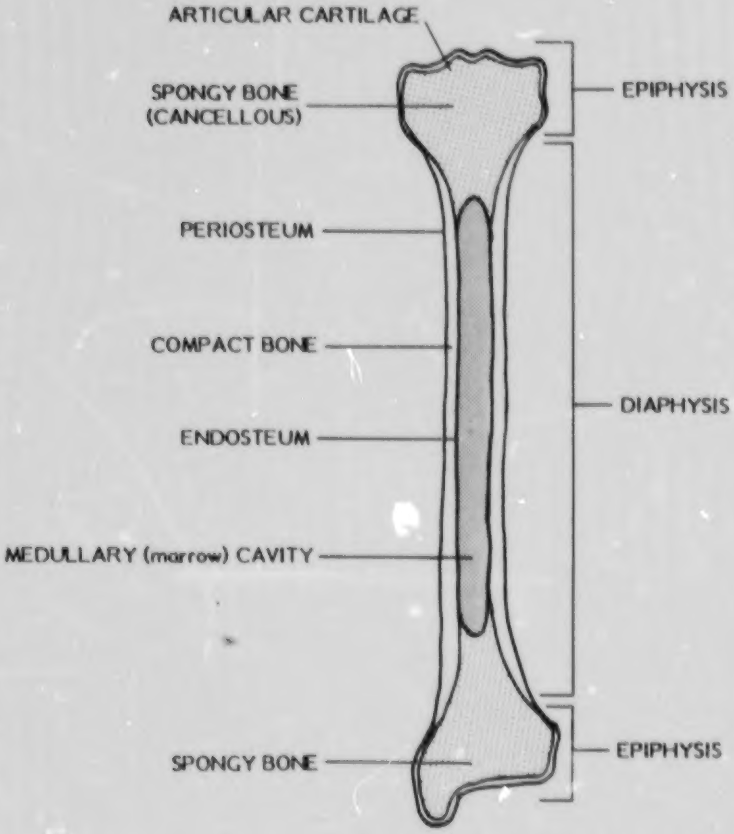
ARTICULAR CARTILAGE
SPONGY BONE (CANCELLOUS)
EPIPHYSIS
PERIOSTEUM
COMPACT BONE
DIAPHYSIS
ENDOSTEUM
MEDULLARY (marrow) CAVITY
SPONGY BONE
EPIPHYSIS

Fig. 1. Diagram of long bone, longitudinal section

AXIAL SKELETON

skull bones					
cranium	frontal			1	
	occipital			1	
	parietal			2	
	temporal			2	
	sphenoid			1	
	ethmoid			1	8
facial bones	turbinate			2	
upper jaw	maxilla			2	
	nasal			2	
cheek	zygomatic (malar)			2	
lower jaw	mandible			1	
	lacrimal			2	
	palatine			2	
	vomer			1	14
spinal column	vertebrae				
	cervical	1 - 7		7	
	thoracic	8 - 19		12	
	lumbar	20 - 24		5	
	sacral	25 - 29	(these fuse in adults to form the sacrum)	5 1	
	coccygeal	30 - 33	(these fuse in adults to form the coccyx)	1	26 (33 in children)
chest (thorax)	ribs (12 pair)			24	
	sternum		(including the xiphoid process)	1	25
inner ear bones	hammer (maleus)			2	
	anvil (incus)			2	
	stirrup (stapes)			2	6
horseshoe-shaped bone	hyoid			1	1

APPENDICULAR SKELETON

Common Name	**Technical Name**		**Number**	
	Upper Extremities			
shoulder girdle	clavicle		2	
	scapula		2	
upper arm	humerus		2	
lower arm	radius		2	
	ulna (little finger side)		2	
wrist	carpals		16	
hand	metacarpals		20	
fingers	phalanges		28	64
	Lower Extremities			
hip girdle (pelvic girdle)	ilium ischium pubis	(these fuse in the adult to form the innominate or hipbone)	2	
thigh	femur		2	
lower leg	tibia		2	
	fibula		2	
kneecap	patella		2	
ankle	tarsals		14	
foot	metatarsals		10	
toes	phalanges		28	62
		Total adult bones		206

Fig. 2. *Axial skeleton and appendicular skeleton*

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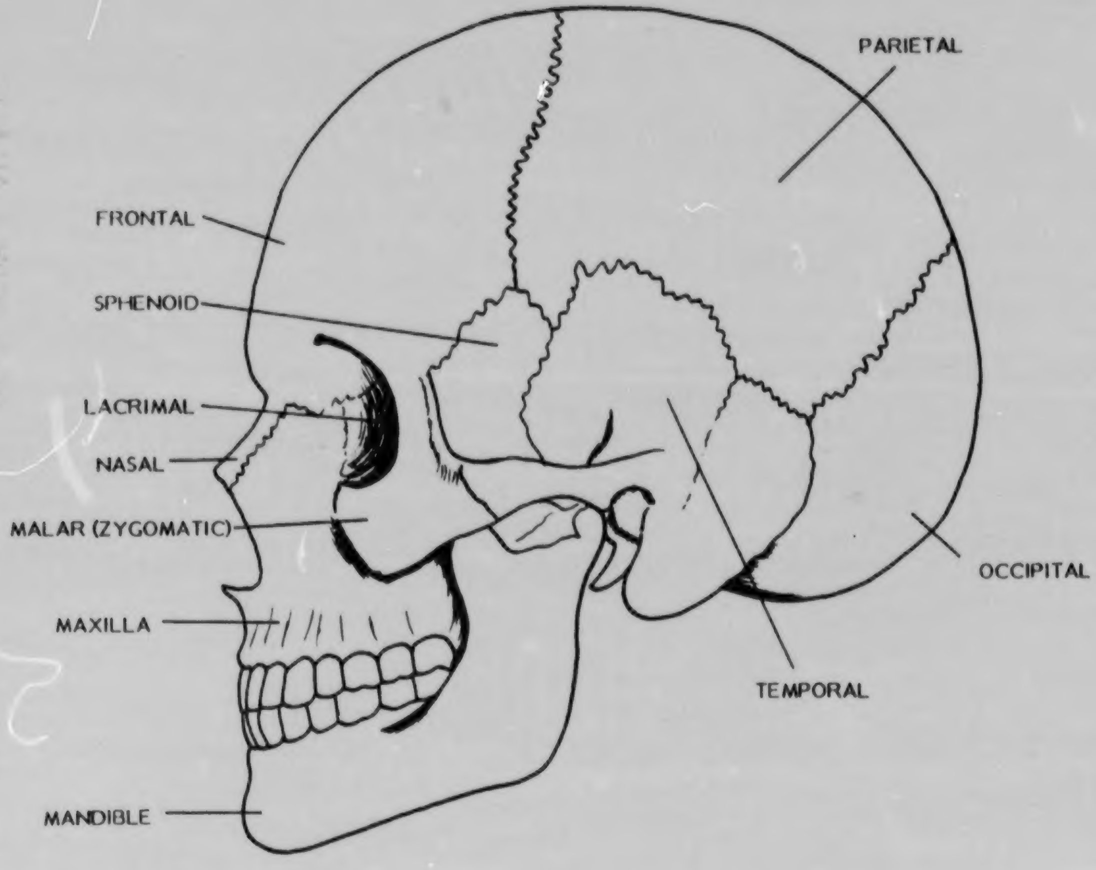

PARIETAL
FRONTAL
SPHENOID
LACRIMAL
NASAL
MALAR (ZYGOMATIC)
MAXILLA
MANDIBLE
OCCIPITAL
TEMPORAL

Fig. 3. Bones of the skull (lateral view)

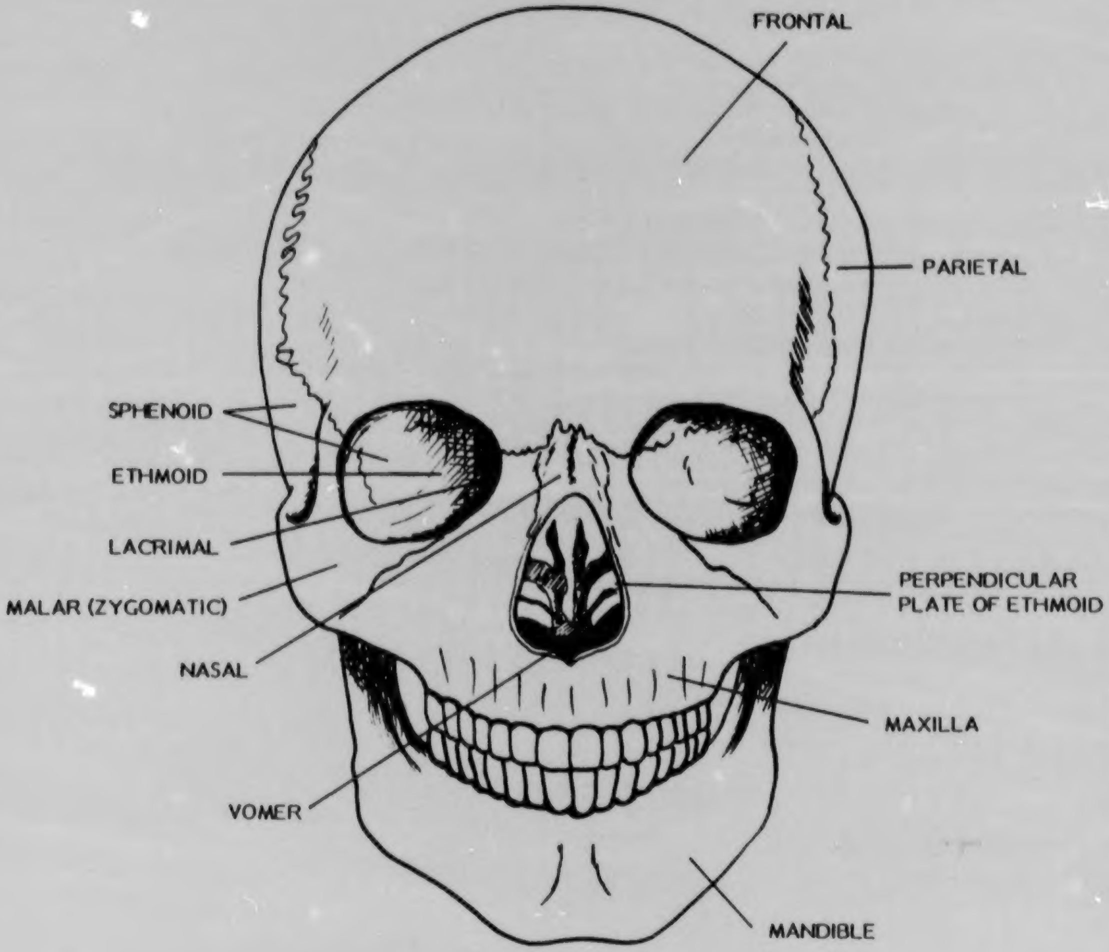

FRONTAL
PARIETAL
SPHENOID
ETHMOID
LACRIMAL
MALAR (ZYGOMATIC)
NASAL
PERPENDICULAR PLATE OF ETHMOID
MAXILLA
VOMER
MANDIBLE

Fig. 4. Bones of the skull (front view)

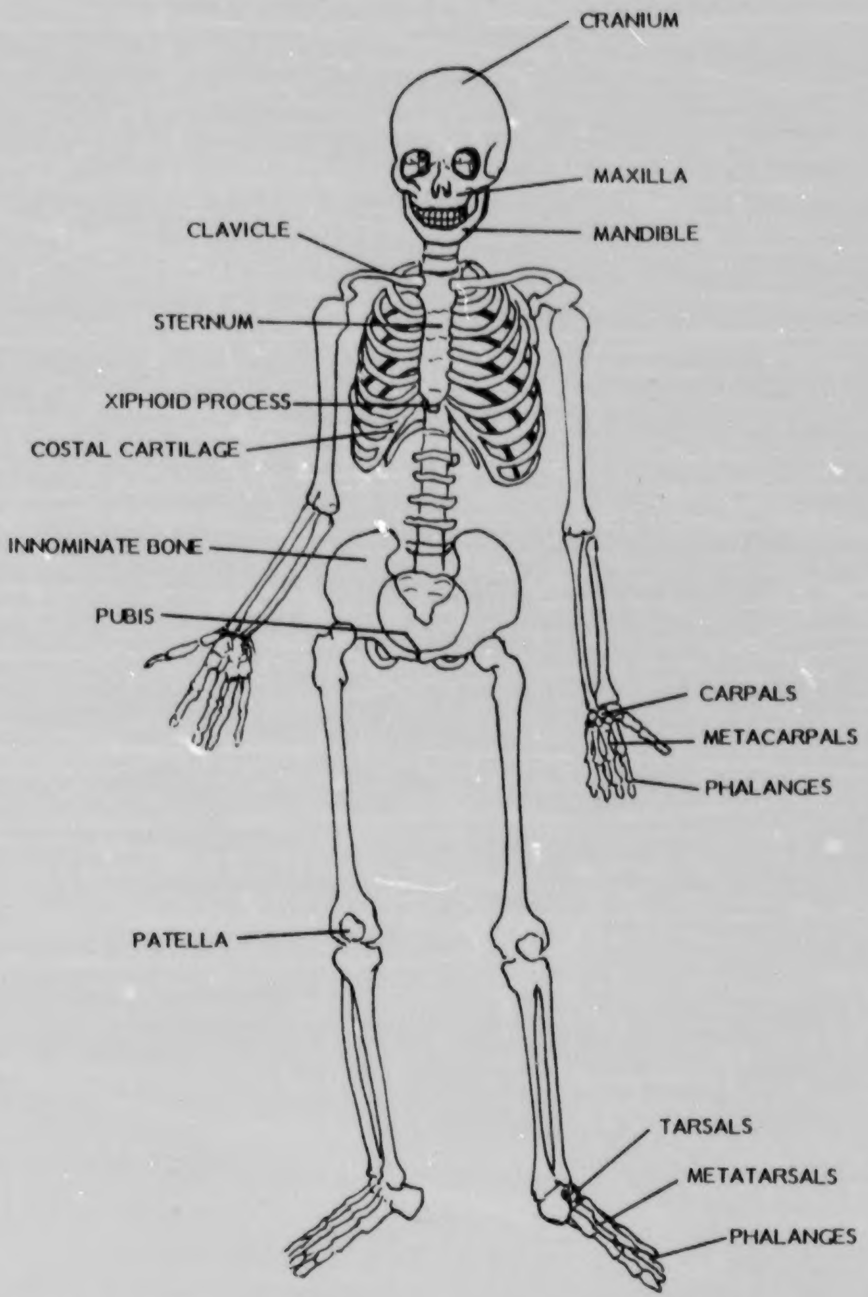
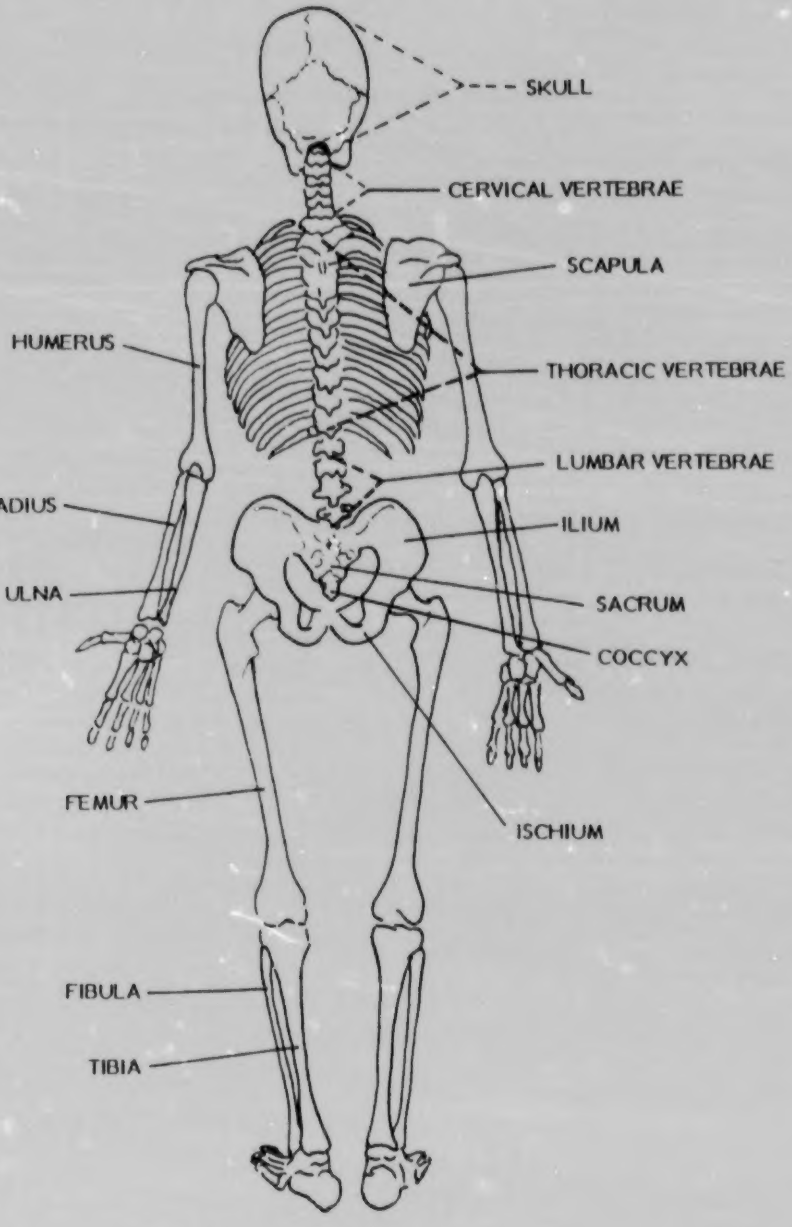

CRANIUM
MAXILLA
MANDIBLE
CLAVICLE
STERNUM
XIPHOID PROCESS
COSTAL CARTILAGE
INNOMINATE BONE
PUBIS
CARPALS
METACARPALS
PHALANGES
PATELLA
TARSALS
METATARSALS
PHALANGES

Fig. 5. Skeleton—anterior and posterior


SKULL
CERVICAL VERTEBRAE
SCAPULA
HUMERUS
THORACIC VERTEBRAE
LUMBAR VERTEBRAE
RADIUS
ILIUM
ULNA
SACRUM
COCCYX
FEMUR
ISCHIUM
FIBULA
TIBIA

The facial bones (fig. 4) include the palatines, which form the hard palate of the mouth and the lateral nasal wall. Also included are the nasal bones, the upper jaw or maxillae, the lower jaw or mandible, and the cheekbones or zygomatic (malar) bones. The lacrimal bones are found at the inner side of the eye cavity. They have a tiny groove that accommodates a portion of the tear or lacrimal duct. The vomer bone forms the lower and back portions of the nasal septum. The nasal conchae or turbinate bones extend from the lateral wall of the nasal cavity. The turbinate bones get their name from their "cone" shape.

The vertebrae make up the spinal column. They protect the spinal cord and help make possible our posture. There are 26 vertebrae in adults and 33 in children. This difference is because several vertebrae fuse in adulthood. The vertebrae are numbered for convenience. The first seven are called cervical vertebrae, and are numbered C1 through C7. The next twelve are the thoracic vertebrae, numbered T1 through T12. These provide dorsal attachment for the ribs. The next five are the lumbar vertebrae, L1 through L5, followed by five sacral vertebrae. Finally, the last vertebrae are the coccygeal vertebrae. In children, there are four to five separate coccygeal vertebrae, which are fused in adults to form the coccyx.

The twelve pairs of ribs protect the delicate organs such as the heart and lungs. The ribs attach to the vertebrae dorsally and to the sternum ventrally. The first seven pairs attach directly to the sternum. The last five pairs attach dorsally but are held in place ventrally by strong cartilage that binds them to the sternum. The last pairs do not actually attach directly to the sternum, and thus are called "floating ribs." This gives the rib cage great flexibility.

The bones of the middle ear are included in the axial skeleton although they are not actually a part of either the axial or appendicular skeleton. These tiny bones, vital to hearing, are discussed in Unit 7.

The hyoid bone is a small U-shaped bone located between the larynx and the mandible. It is unique in that it does not attach to any other bone, but rather is suspended from the styloid process of the temporal bone of the skull. It is very important because it provides attachment for some of the muscles of the tongue.

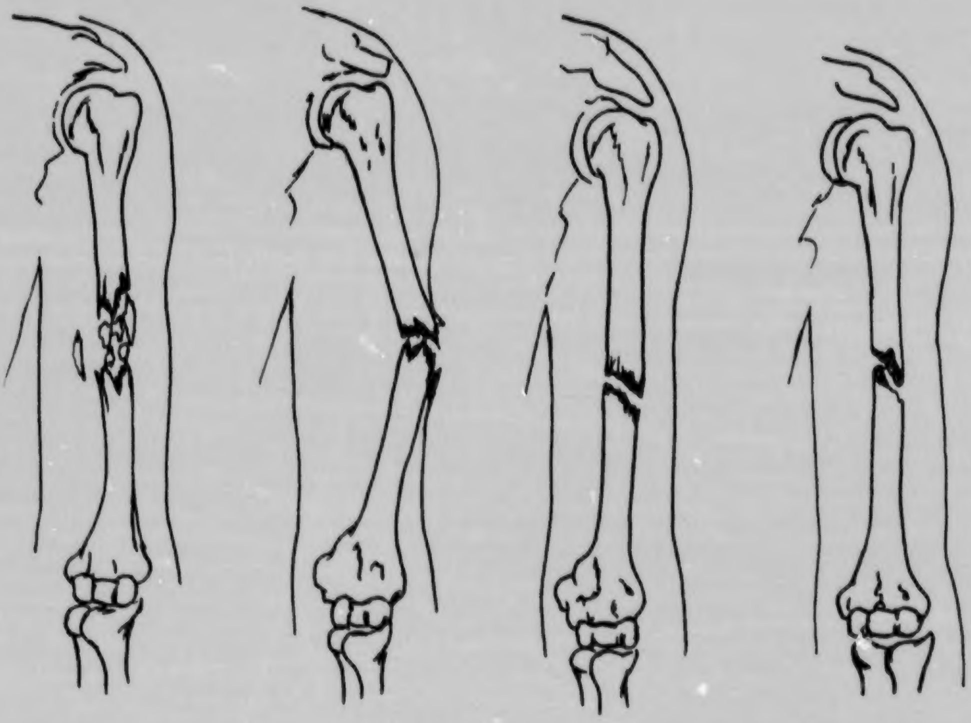
The **appendicular skeleton** includes all of the bones of the upper and lower extremities. The shoulder girdle is made up of the clavicle and scapula. The humerus of the upper arm, the radius and ulna of the lower arm, the carpals of the wrist, the metacarpals of the hand, and the phalanges or fingers of the hand make up the bones of the arm and hand. The bones of the hip or pelvic girdle include the ilium, ischium, and pubis, which fuse in adults to form the innominate or hipbone. The bones of the leg are the femur or thigh bone, the patella or kneecap, the tibia, and the fibula. The bones of the ankle are the tarsals. The metatarsals are the bones of the foot, and those of the toes are phalanges (fig. 5).

Some parts of the skeletal system are made of cartilage rather than bone. **Cartilage** is a specialized type of connective tissue. It has no nerve or blood supply of its own. Therefore, food and oxygen enter and wastes leave cartilage cells by diffusion. Cartilage is tough, flexible, somewhat elastic material. It lacks the mineral deposits of bone, and instead is built around a matrix of collagen fibers embedded in a gel-like substance.

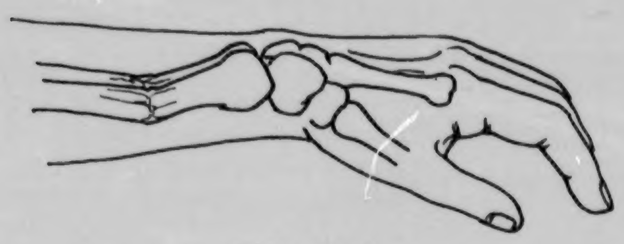
Temporary cartilage is found in infants and young children and is gradually replaced by bone in adults. Permanent cartilage remains throughout life. It is found in body parts where strength with flexibility is required. Examples are the external ears, the end of the nose, the tracheal rings, and the rib attachments.

Types of Fractures

No discussion of bones is complete without mentioning broken bones. Actually, the skeletal system is so efficient that breaks occur infrequently, despite the stress and trauma of our life activities. Any break in a bone is called a fracture, but there are several common descriptive terms used for specific fractures (fig. 6). In a **simple fracture,** the bone is broken but there is no external wound as a result of the injury. A **compound fracture** means that a bone is broken and that the skin and soft tissue are torn. The broken ends of the bone protrude through the injured tissue and skin.



COMMINUTED COMPOUND SIMPLE SPIRAL



GREENSTICK

Fig. 6. Types of fractures

Greenstick fractures sometimes occur in young children. This means that some of the bone tissue is broken while the remaining tissue is bent. A **comminuted** fracture means that the bone is splintered at the site of the injury. Small pieces of the bone may be embedded in tissue surrounding the two main fragments. If the bone is twisted apart, the resulting fracture is **spiral**. Fractures are sometimes further described according to the direction or location of the fracture, such as longitudinal, transverse, or oblique.

When a bone is fractured, the body immediately begins repair. Blood resulting from the injury forms a clot about the injured bone tissue. Osteoblasts form a loosely woven bone tissue around the injured bone ends. Then bone is laid down to knit the fractured ends together again. Fractures heal more successfully if the broken ends are in close and accurate contact. Sometimes broken bones are held together with casts, bandages, or pins.

Types of Movement

Joints, or articulations, are points at which two bones come together. Movement of heavy bones, as well as the overall maneuverability of the body, would be impossible without joints. The type of movement at joints is determined by the structure of the individual joint (fig. 7). **Flexion** is the movement that decreases the size of an angle. **Extension,** on the other hand, is the motion that straightens a joint. The movement of the elbow is a good example. Flexion brings the forearm close to the humerus and decreases the size of the angle, while extension straightens the arm. **Abduction** is a motion that moves a bone away from the body, and **adduction** moves a bone toward the body. If you move your arms away from your body, that's an example of abduction; returning the arms to the sides is adduction. **Rotation** is the movement of a bone on its own axis. Turning your head from side to side is an example of rotation. **Circumduction** means to move one end of a bone in a circle while the other end remains stationary. This movement involves all of the movements described—abduction, flexion, adduction, extension, and rotation. An example would be to move outstretched arms in a complete circle.

Types of Joints

The types of joints are classified by their function or movement and include hinge, ball and socket, gliding, pivot, partially movable, and immovable (fig. 8). They may also be classified using different terminology, but still by the movement they permit, as diarthroses, amphiarthroses, and synarthroses. A **diathrosis** is a joint that is freely movable, such as gliding, hinge, pivot, or ball and socket joint. An **amphiarthrosis** is a joint that is slightly movable, and a **synarthrosis** is an immovable joint.

In a **hinge joint** (diarthrosis), the concave end of one bone fits over the convex end of another. This permits movement in one direction only, but provides strong support. Examples are hinge joints of the elbow, knee, and fingers.

In a **ball and socket joint** (diarthrosis), the ball-shaped end of one bone fits into the hollow of another bone. Examples are the hip and shoulder. This type of joint provides great freedom of motion: extension, flexion, abduction, adduction, and rotation.

In a **pivot joint** (diarthrosis), one bone end rotates in a ring around the other. Examples are the head on the vertebral column, or the head of the radius on the distal end of the humerus. This type of joint provides rotation or a turning motion.

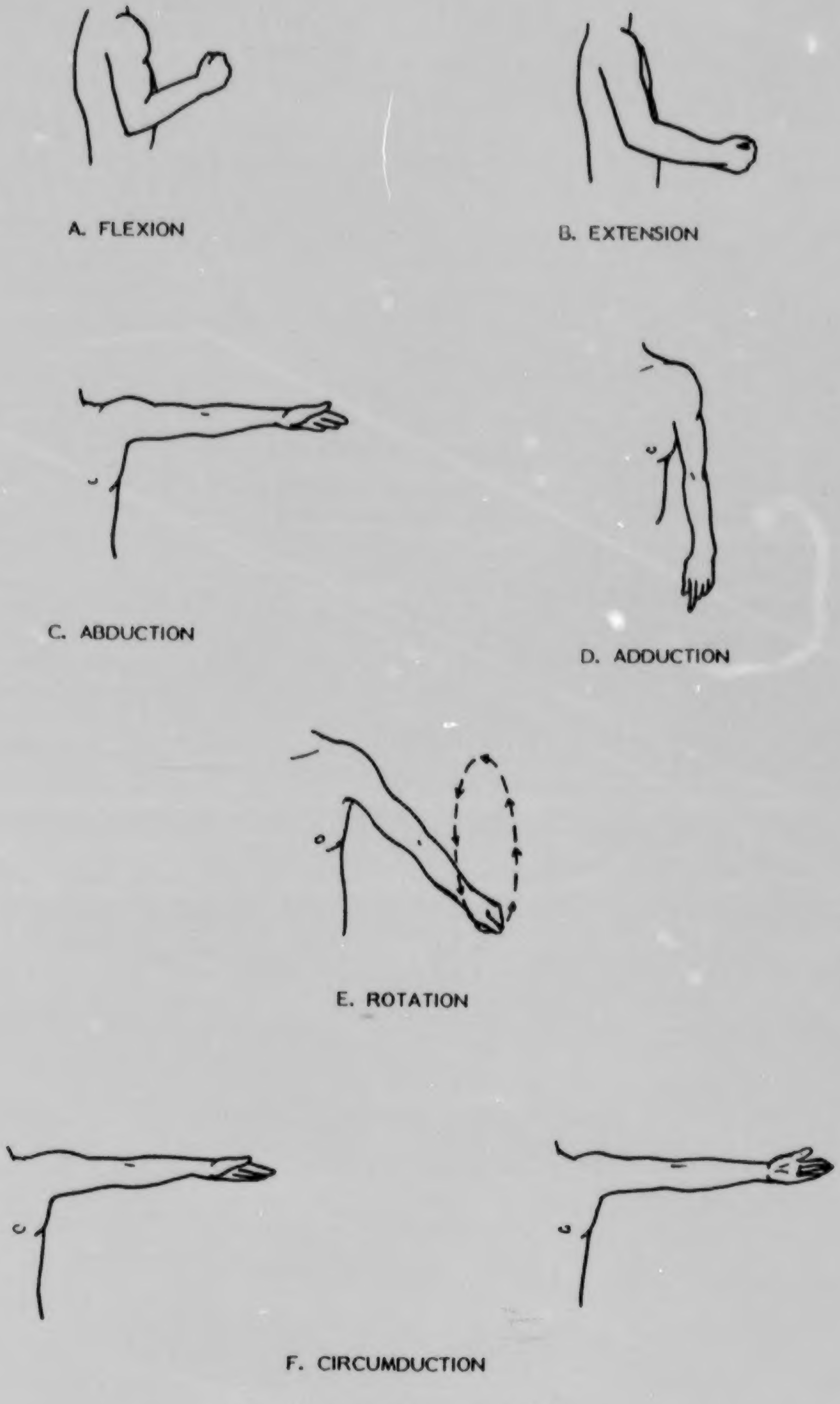
Examples of a **gliding joint** (diarthrosis) are found in the tarsi of the ankle or the carpals of the wrists. In gliding joints, the surface of one bone glides across the surface of another. This type of joint allows limited motion, but strong support.

In an **immovable joint** (synarthrosis), the bones come together, but no motion is possible. However, an immovable joint provides maximum protection for body parts. The best example is the bones of the adult cranium. The jointed aspect provides some resilience in case of injury, but the immovability gives protection for the brain.

Partially movable joints (amphiarthrosis) provide limited motion. Examples are the ribs and the spinal column.

Diseases and Disorders

There are many diseases specific to bones (see table 1). One of the best known is arthritis. Actually, arthritis is a category



A. FLEXION

B. EXTENSION

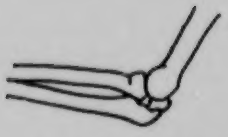
C. ABDUCTION

D. ADDUCTION

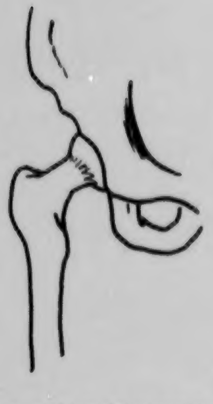
E. ROTATION

F. CIRCUMDUCTION

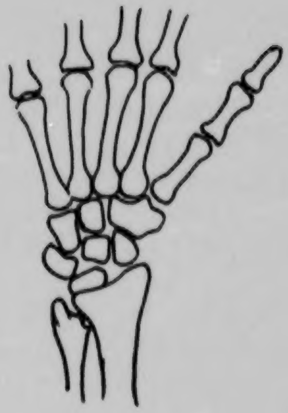
Fig. 7. Types of movement at joints



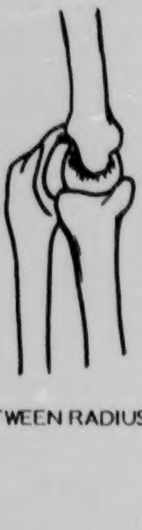
A. HINGE (ELBOW)



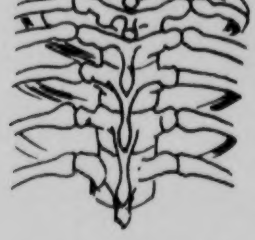
B. BALL AND SOCKET (HIP)



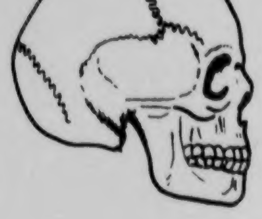
C. GLIDING (WRIST)



D. PIVOT (BETWEEN RADIUS AND HUMERUS)



E. PARTIALLY MOVABLE (RIBS AND SPINE)



F. IMMOVABLE (CRANIAL BONES)

Fig. 8. Types of joints

TABLE 1

Bone Diseases and Disorders

arthritis—inflammation of the bones at the joints, usually with pain and changes in bone structure.

bunion—abnormal lateral displacement of big toe causing inflammation and thickening of the bursae.

bursitis—inflammation of the bursa, which is a sac or cavity filled with synovial fluid.

dislocation—the displacement of bone from a joint, tearing ligaments, tendons, and capsules.

fracture—a break in a bone.

kyphosis—increase in natural curvature of the spinal column with resulting hunchbacked appearance.

lordosis—exaggerated inward curvature in the lumbar region of the spinal column.

osteitis—inflammation or infection of the bone.

osteomyelitis—bone infection that involves bone marrow.

osteoporosis—condition in which bones become softer and more brittle, and thus more liable to fracture because of loss of mineral content. This condition is usually associated with aging.

rickets—condition in which bones fail to calcify and growth is hampered, usually due to a deficiency of vitamin D and phosphorus in the diet.

scoliosis—side to side curvature of the spinal column.

spina bifida—congenital defect in which the vertebrae fail to unite at the midline.

sprain—wrenching of a joint with injury to ligaments.

tuberculosis (of bone)—invasion of bone by tubercle bacilli, **Mycobacterium tuberculosis.**

of diseases which is characterized by inflammation of the bones at the joints, usually accompanied by pain and actual changes in bone structure. Perhaps the best-known type of arthritis is **rheumatoid arthritis.** This disease may affect people of any age, but occurs more often in those between 30 and 50 years of age, and more often in women than men. The cause is unknown, but symptoms include swelling, pain, and inflammation of the joints.

Another common form of arthritis is **osteoarthritis** or degenerative joint disease. In this disease, the joints appear to wear and become irritated. The cause is unknown, but it seems to occur more often in older patients who have suffered joint trauma or in patients who are obese.

Infectious arthritis is the term used for arthritis caused by bacterial infection. Although other bacteria are known to cause infectious arthritis, the most common offender is the gonococcus. The knee, wrist, and angle are the joints most commonly affected. The arthritis almost always occurs at the same time the patient has a genital gonorrheal infection.

Another disease associated with bones and joints is **bursitis.** A bursa is a sac or cavity usually found at joints or between tendons and bones. A common example of bursitis is bunion. This is an inflammation and thickening of the bursa of the big toe. These changes force the big toe inward toward the little toe. Sometimes bunions are caused by wearing shoes that do not fit properly. High-heeled shoes especially cause an unnatural distribution of body weight, which in turn causes pressure on the bursa of the big toe. Another common form of bursitis is tennis elbow (radiohumeral bursitis). The elbow becomes painful, and the pain radiates down the outer side of the arm. The pain increases when the wrist is moved as in using a screwdriver or a tennis racket. Housemaid's knee (prepatellar bursitis) results from pressure on the patella, such as from kneeling for long periods of time. Tailor's or weaver's bottom (ischial bursitis) is another kind of bursitis. It results from improper sitting posture with pressure on the ischium. All of these types of bursitis are caused by unusual pressure on a bursa.

There are several types of curvatures of the spinal column. **Kyphosis** refers to an exaggeration of the natural posterior curve, which causes a hunchbacked appearance. **Lordosis** is an exaggerated inward curve of the lumbar region of the spinal column. **Scoliosis** refers to a side to side curvature.

Any infection or inflammation of the bone is **osteitis.** If the infection involves the bone marrow, the disease is **osteomyelitis.**

Osteoporosis is a bone disease usually found in older people. Bone becomes abnormally porous because of a loss of minerals. The activity of bone-building osteoblasts and bone-destroying osteoclasts is regulated in part by sex hormones. With advancing age, fewer sex hormones are produced. The osteoclasts are more active than the bone-building osteoblasts with a resulting loss of bone tissue. The bones become porous and brittle, and the chances of fracture and deformity increase.

Rickets is a disease usually of children, in which the bones fail to calcify sufficiently due to a vitamin D deficiency. Growth may be slowed, and sometimes deformities such as bowleg may result from rickets.

Dislocations and sprains are usually caused by accidents or injuries. A **dislocation** means that a bone is displaced from a joint with tearing of the ligaments, tendons, and capsules. A **sprain** is a condition caused by wrenching a joint with injury to ligaments.

3

The Muscular System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the muscular system;*
2. *list three functions of muscles;*
3. *list three types of muscles;*
4. *give the general structure of a skeletal muscle;*
5. *list the parts of a muscle cell;*
6. *explain how a muscle contracts;*
7. *discuss energy release in skeletal muscles;*
8. *explain "oxygen debt";*
9. *explain the origin and insertion of skeletal muscles;*
10. *give ways in which muscles are named;*
11. *identify several muscles from a diagram, chart, or model;*
12. *identify common disorders of muscles;*
13. *demonstrate three sites for intramuscular injection; and*
14. *tell what drug implantation means.*

New Terms and Definitions

aerobic respiration—cellular respiration in which atmospheric oxygen is used.

anaerobic respiration—cellular respiration in which atmospheric oxygen is not used; pyruvic acid is the source of energy.

aponeurosis—a flat, fibrous sheet of tissue that serves as an attachment for muscles to bone or other tissue.

endomysium—tissue that covers individual cells in a muscle.

epimysium—tissue that covers the outside surface of muscle; fibrous, connective tissue.

fascia—a fibrous membrane that covers, supports, and separates muscles.

homeostasis—a state of equilibrium that the body maintains by constant self-regulating adjustments.

insertion—the place of attachment of a muscle to a bone which it moves.

origin—the more fixed end or attachment of a muscle, as distinguished from its insertion.

perimysium—fibrous connective sheath as it surrounds individual bundles of muscle fibers.

striated—striped; marked by streaks.

tendon—fibrous tissue that attaches muscle to bone (an extension of the epimysium).

viscera—internal organs enclosed within a cavity, especially abdominal organs.

Functions of the Muscular System

Motion is one of the most important functions of the muscular system. The ability to move makes it possible for humans to function in their environment. One has only to have limited motions temporarily to realize its importance in performing daily activities.

Skeletal muscles, along with the bones of the skeletal system, make possible locomotion of the body and its parts. The movement of internal organs, such as the diaphragm in breathing, the movements of the digestive tract, or the beating of the heart, is also made possible by muscles.

A second function of muscles is to assume and maintain body positions or posture. Muscles make it possible to stand, sit, kneel, stoop, or assume any other posture. The skills of athletes and dancers, musicians or typists, all require muscle training.

A third important function of muscles is to help maintain a constant or homeostatic body temperature. As you know, **Homo sapiens** is warm-blooded and maintains the same temperature independent of environmental factors. The muscular system, because of its mass or size, produces large quantities of body heat that can be transported throughout the body by means of the circulating blood.

Types of Muscles

The three types of muscle tissue are skeletal, smooth, and cardiac (fig. 1). **Skeletal muscles** make up about 40 to 50 percent of our body weight. As the name implies, they are attached to bones. With the bones, they provide movement. Skeletal muscles are also called **voluntary** muscles because they can be moved at will. And because their structure gives them a striped appearance, they are sometimes called striated muscles.

Smooth muscles control body activity that goes on below the level of consciousness, such as digestion, glandular secretion, or normal breathing. Because internal organs or viscera are controlled by smooth muscles, they are also called visceral muscles. Sometimes they are called **involuntary** muscles because they carry on their activity below the level of consciousness or without the volition of the individual. Even breathing is essentially involuntary because breathing centers in the brain control breathing. Of course, it is possible to take a deep breath or to hold your breath, but, as you are aware, in a very short time you must breathe, or lose consciousness. Then the nervous system signals the breathing centers to initiate breathing again.

Cardiac muscle is involuntary and striated. Thus, it combines characteristics of each of the other types, yet is different from either. Cardiac muscle is found only in the heart. It is unique in that heart muscle begins to beat early in embryonic life and continues its work every second until life ends.

Structure of Muscles

A closer look at the structure of a skeletal muscle will help in understanding how it functions. The outside surface of a muscle is covered by a fibrous connective sheath called the **epimysium.** It folds inward to cover individual bundles of muscle fibers. When the epimysium surrounds each individual bundle, it is called the **perimysium.** It even extends to cover individual muscle cells and is then called the **endomysium.** In this way the endomysium, perimysium, and epimysium are continuous and are also continuous with the fibrous tissue that forms a tendon. Tendons are continuous with the periosteum of bone. They firmly attach muscles to the bones and move when muscles contract (fig. 2).

Skeletal muscle cells are unique in that they have multiple nuclei. The cells are often spoken of as muscle fibers because of their long and threadlike shape. Although muscle cells have the same parts as other cells, some different terms are used. The sarcoplasm corresponds to the cytoplasm, the sarcolemma corresponds to the plasma membrane, and the sarcoplasmic reticulum corresponds to the endoplasmic reticulum. Muscle cells, as you may have guessed, have many mitochondria.

Muscle cells are made up of many long, slender threads, or **myofibrils.** These strands lie parallel and extend lengthwise throughout the cell. Myofibrils, in turn, are made of even smaller strands called **myofilaments.** There are two different kinds of these—a thick myofilament made of protein myosin and called an A band, and a thinner myofilament made primarily of the protein actin and called an I band. These myosin and actin bands are stacked alternately to form a sarcomere (fig. 3).

Much is known about the molecular structure of myofilaments, but the details of the processes of energy release and muscle contraction is too complex for this study. The following brief discussion will provide an introduction to the process. Muscle fiber contraction is explained by the "sliding-filament theory." It is believed that when a nerve impulse reaches a myofibril, it stimulates the myofibril to contract.

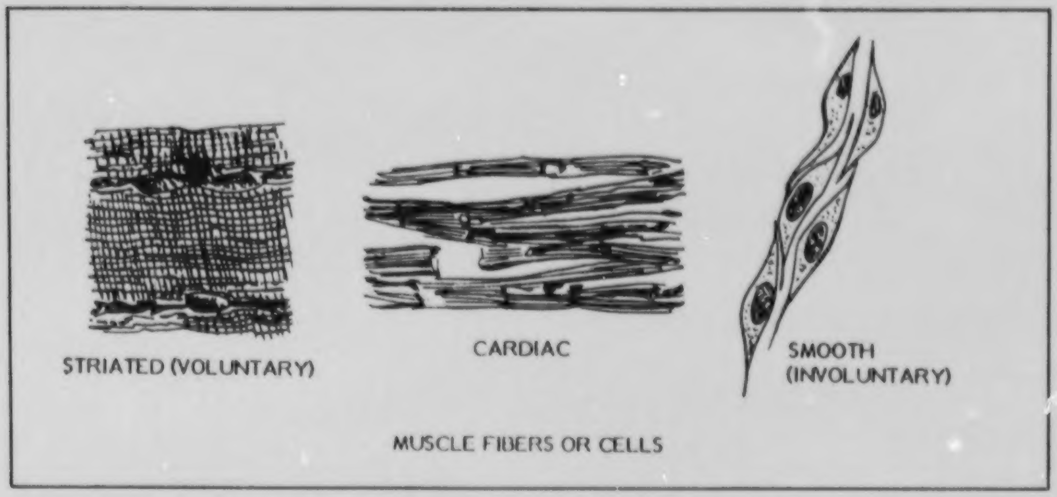

STRIATED (VOLUNTARY)
CARDIAC
SMOOTH (INVOLUNTARY)
MUSCLE FIBERS OR CELLS

Fig. 1. *Types of muscle cells (skeletal, visceral, cardiac)*

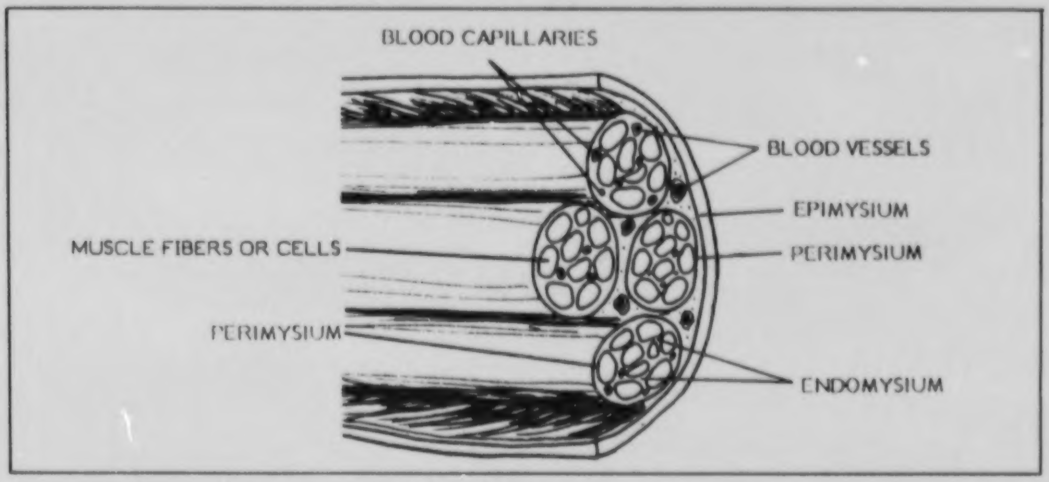

BLOOD CAPILLARIES
BLOOD VESSELS
EPIMYSIUM
MUSCLE FIBERS OR CELLS
PERIMYSIUM
PERIMYSIUM
ENDOMYSIUM

Fig. 2. *Muscle structure*

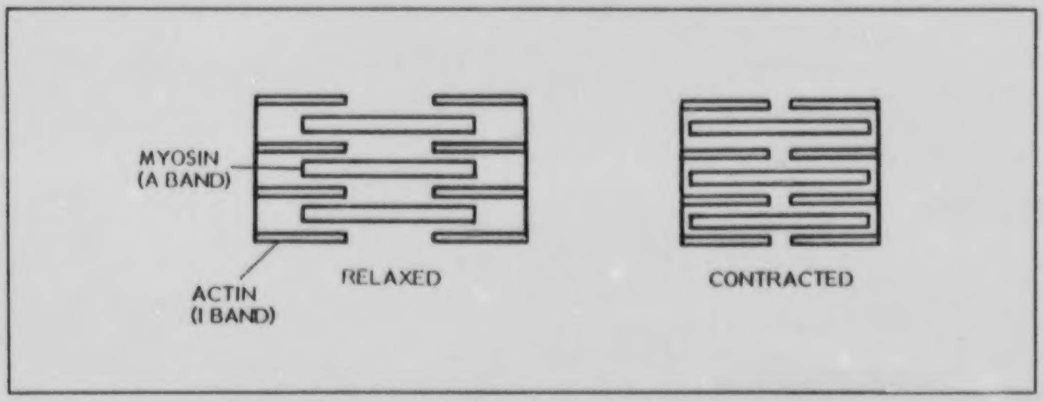

MYOSIN
(A BAND)
ACTIN
(I BAND)
RELAXED
CONTRACTED

Fig. 3. *Diagram showing A bands and I bands of a sarcomere*

Energy is released for the process. The thick myosin (A) myofilaments and thin actin (I) myofilaments slide over one another. As the myofibrils move, the sarcomere contracts. With the contraction of multiple sarcomeres, the muscle contracts. (Note the difference in the position of the A bands and the I bands in the relaxed and contracted positions in figure 3.)

Energy is required for muscle contraction. This energy is supplied to the cells by aerobic respiration in which glucose combines with oxygen with the release of energy. If the oxygen supply is inadequate for cellular needs, as in strenuous or prolonged exercise, pyruvic acid provides energy without using free oxygen. This is called anaerobic respiration. When pyruvic acid breaks down to liberate energy, lactic acid is given off. Lactic acid accumulates in the tissues and causes a feeling of fatigue. "Oxygen debt" results from the lactic acid buildup. **Oxygen debt** is the condition that occurs when, because of great muscular activity, the body is unable to supply enough oxygen for adequate aerobic respiration, and anaerobic respiration takes place. Muscle cramps or spasms following prolonged exercise are examples of the results of anaerobic respiration.

The accumulated lactic acid also stimulates an increased respiration rate and heartbeat. Thus, more oxygen is made available for aerobic respiration, and the oxygen debt is paid. During rest, as more oxygen is taken in, the accumulated lactic acid is oxidized, some is converted to glycogen and stored, and some is converted to carbon dioxide and water and excreted. Gradually, normal breathing and heartbeat are restored. However, if the muscular activity continues, the buildup of lactic acid increases and the muscle contractions become weaker until the muscle fibers finally do not respond at all and collapse may ensue.

Movement is a major function of muscles. However, the only movement of which they are capable is contraction followed by relaxation. Skeletal movement is attained by the pulling action on bones to which the muscles are attached.

Individual muscle cells contract on the "all-or-none" principle. That is, all of the myofibrils of a cell contract when stimulated. Muscle action is determined by several factors, including oxygen and food supply, the number of fibers stimulated, and the extent of activity required.

Skeletal muscles have two or more attachments, usually to bones. The more fixed end or attachment of the muscle to bone is called the **origin.** The place of attachment of a muscle to a bone which it moves is called the **insertion.** Thus, the origin of the biceps brachii that you observe when you bend your elbow is at the scapula, which does not move; the insertion is at the radius, which does move (fig. 4).

Most muscles are modified for their specific type of action. The following are examples of terms that indicate various functions of muscles:

flexor—muscle that bends a joint.

extensor—muscle that extends a part or increases the angle of a joint.

abductor—muscle that moves a part away from the midline of the body.

adductor—muscle that moves a part toward the midline of the body.

rotator—muscle that revolves a part on its axis.

sphincter—circular muscle that closes an opening. (See Unit 2 for illustrations.)

Skeletal muscles are named according to one or more of the following: action, shape, origin and insertion, number of divisions, location, size, and the direction of the muscle fibers. Action terms incorporated in the muscle's name are flexor, extensor, abductor, adductor, and so on. Examples of muscles that indicate shape are the deltoid (or triangular shape) and the trapezius (shaped like a trapezoid).

The sternocleidomastoid is an example of a muscle named for its origin and insertion. The origin is at the sternum and clavicle, and the insertion is at the mastoid process. The number of divisions of a muscle are indicated in the biceps, triceps, or quadriceps.

Names that reflect the location of a muscle refer to the skeletal region where it is found, such as the tibialis or radialis. Examples of terms that indicate the direction of fibers are **rectus,** which means parallel to the midline of the body, **transverse,** which is perpendicular to the long axis of the body, and **oblique,** which is diagonal to the long axis.

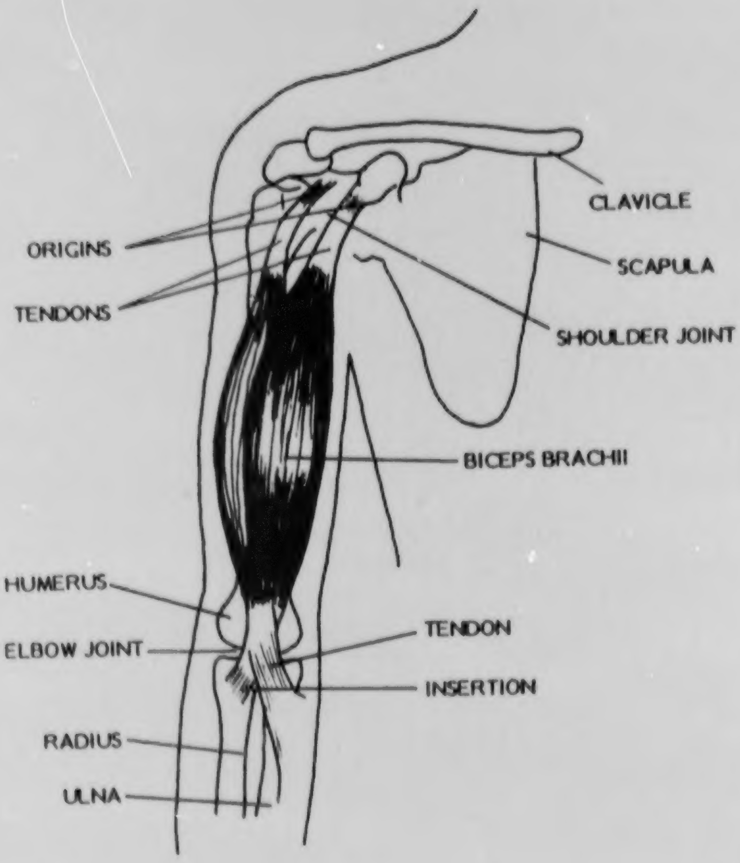

CLAVICLE
ORIGINS
SCAPULA
TENDONS
SHOULDER JOINT
BICEPS BRACHII
HUMERUS
TENDON
ELBOW JOINT
INSERTION
RADIUS
ULNA

Fig. 4. Origin and insertion of biceps brachii

Muscles named for their size are those with titles such as brevis (short), minimus (smallest), and maximus (largest). Names such as gluteus maximus and gluteus minimus are examples.

Since there are over 400 muscles in the body, it is not necessary that you memorize the name and function of each. However, it will be helpful to be thoroughly acquainted with the names, origins, insertions, and functions of a few. Figures 5 and 6 show some muscles, and table 1 gives names, origin, insertion, and action. Your instructor will tell you which ones you should know.

Tendons are extremely tough, pliable fibrous tissue that attach muscles to bone. Some tendons, such as those of the wrist and ankle, are encased in a sheath composed of fibrous connective tissue and lined with synovial tissue to ensure ease of movement. The most common type of injury to a tendon is to be severed, or in some way pulled away from its attachment to the bone. These injuries must be repaired to restore movement to the affected bone.

Another kind of attachment for muscles is an **aponeurosis.** This attachment is a flat sheet of fibrous connective tissue that provides a large surface area for the attachment of muscles. An example is found in the sole of the foot, or the anterior abdominal wall (fig. 6).

Muscle Sites for Injections

Muscles are often used as sites for injection of medication. The ideal muscle site is deep in a muscle and away from major nerves, blood vessels, or bones. Large muscles should be used to ensure absorption of the medicine. The most frequently used muscles are the gluteal, deltoid, and vastus lateralis (fig. 7).

In choosing a site in the gluteus, the best area is the upper and outer quadrant. The injection should be given 2 to 3 inches below the iliac crest.

To find the area of the vastus lateralis that is best for injection, measure 3 to 4 inches downward from the trochanter and 3 to 4 inches upward from the patella. The space between these two points should be a safe site.

If the deltoid is to be used, the spot about an inch below the acromium process will be safe from the danger of injury to the radial nerve.

In giving intramuscular injections, it is important to use sharp needles of appropriate size. Before injecting medicine, always pull back on the plunger to be sure the needle is not in a blood vessel. Also, remember that drugs suitable for use in intramuscular injection are not appropriate for intravenous use.

A new method of drug administration is the use of implantable systems. This means that the drug is implanted in the tissue. This may be an answer to the problem of maintaining a constant drug level over a period of time. One method is to place a pellet of the drug under the skin, where it is gradually absorbed at a constant rate. This method is being used to treat some hormone deficiencies and for conception control.

Implantable pumps are devices placed under the skin and connected to a blood vessel. The drug enters the blood at a constant rate. It is hoped that this method can be used in the control of diabetes, to administer heparin, and to treat many other long-term or chronic diseases.

Disorders and Diseases

As with any body part, muscles are subject to disorders and diseases. The following list and brief descriptions are meant to identify only the most common.

contracture—permanent shortening of a muscle usually caused by formation of fibrous tissue to replace muscle cells. May occur in immobile patients.

muscle cramps—painful, spasmodic, muscle contraction of longer duration.

muscle spasm—sudden, involuntary muscle contraction of short duration.

muscular dystrophy—disease in which the muscle cells degenerate, so that muscles waste away and atrophy. No cause or cure is now known.

myalgia—muscle pain.

myasthenia gravis—poorly understood disease with muscle weakness and great fatigue. Nerve impulses fail to initiate normal muscle contractions. Patients usually have drooping eyelids and an inattentive appearance.

myositis—inflammation of muscle tissue.

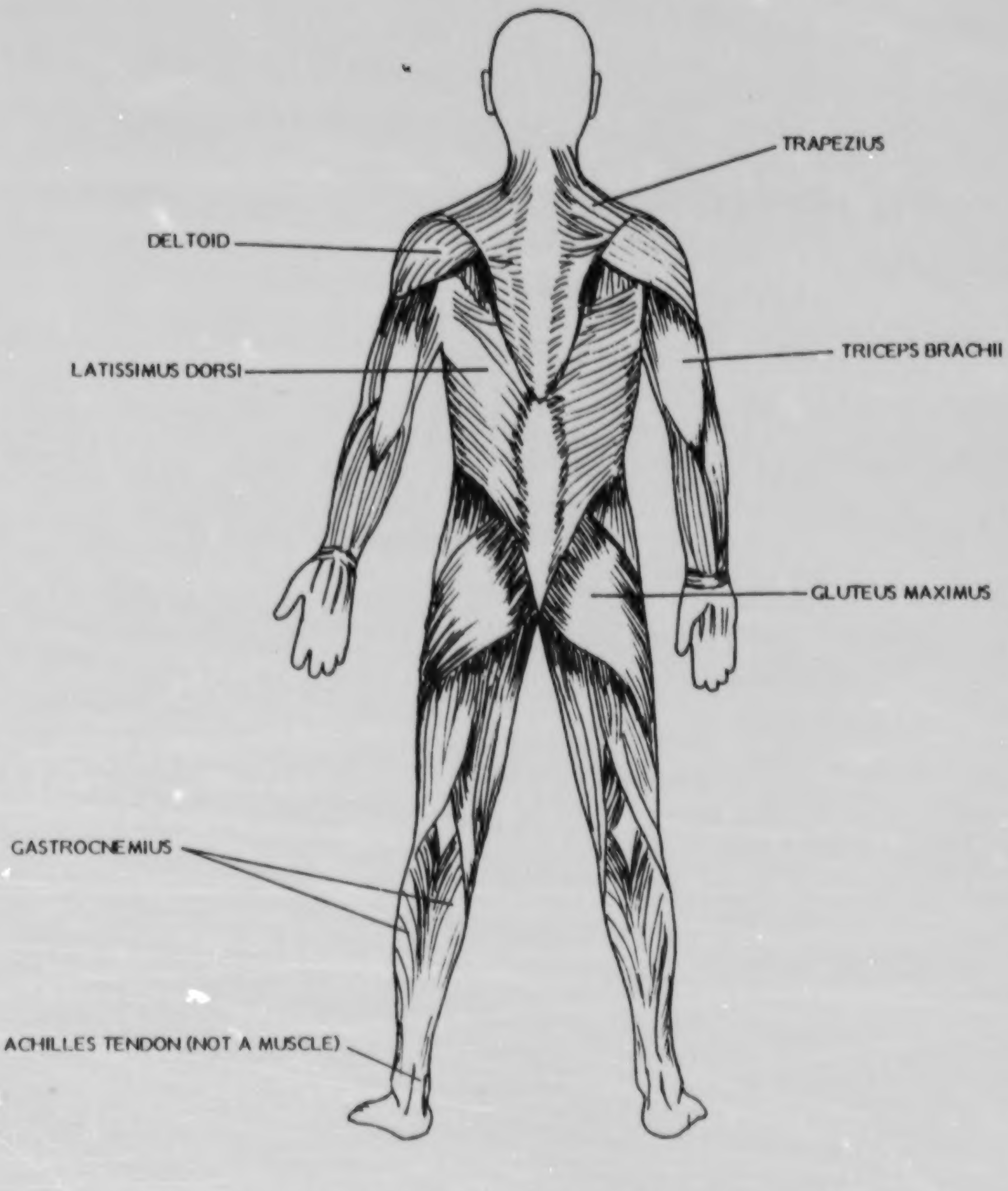

TRAPEZIUS
DELTOID
TRICEPS BRACHII
LATISSIMUS DORSI
GLUTEUS MAXIMUS
GASTROCNEMIUS
ACHILLES TENDON (NOT A MUSCLE)

Fig. 5. Skeletal muscles (posterior view)

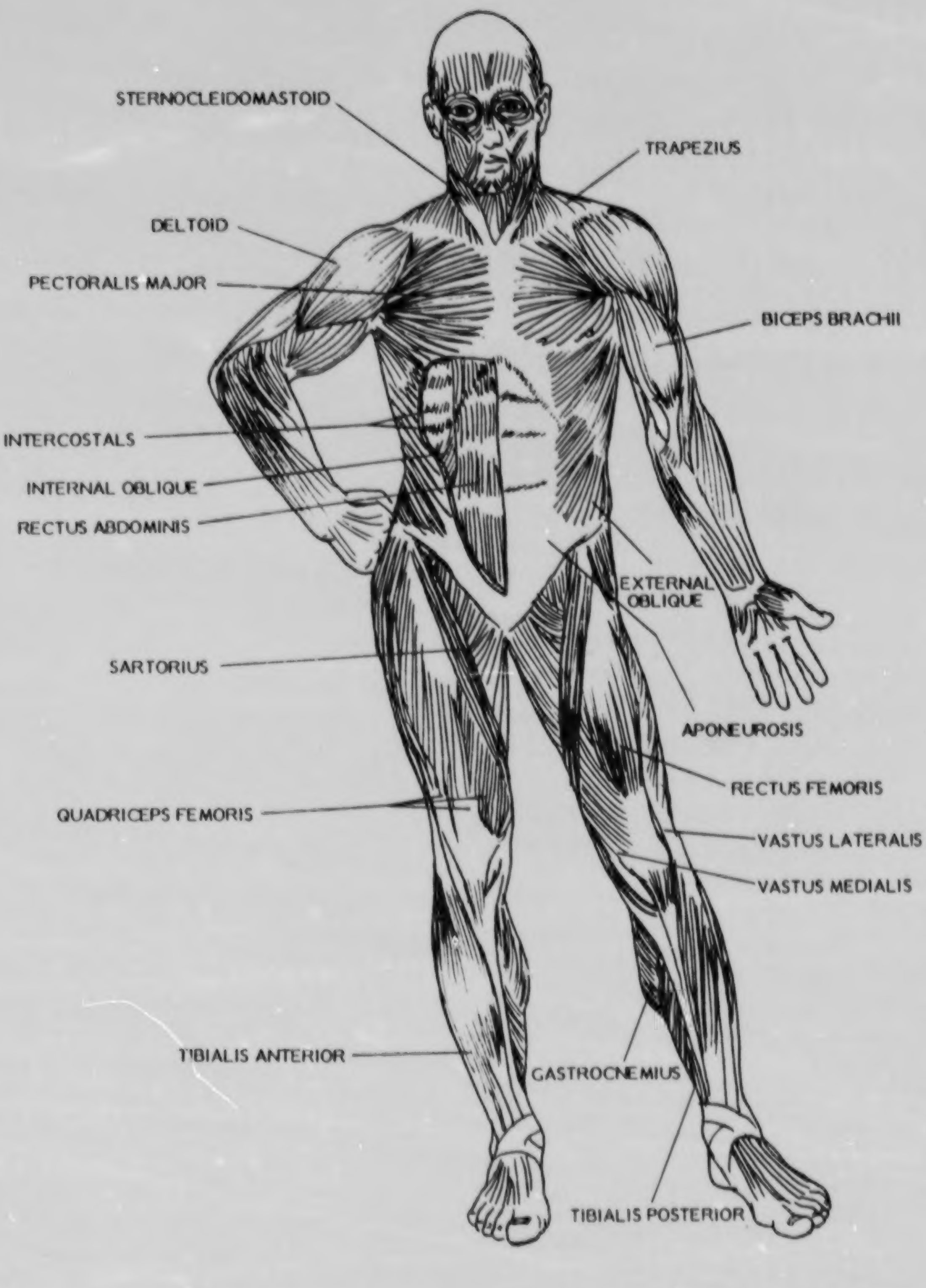

STERNOCLEIDOMASTOID
TRAPEZIUS
DELTOID
PECTORALIS MAJOR
BICEPS BRACHII
INTERCOSTALS
INTERNAL OBLIQUE
RECTUS ABDOMINIS
EXTERNAL OBLIQUE
SARTORIUS
APONEUROSIS
RECTUS FEMORIS
QUADRICEPS FEMORIS
VASTUS LATERALIS
VASTUS MEDIALIS
TIBIALIS ANTERIOR
GASTROCNEMIUS
TIBIALIS POSTERIOR

Fig. 6. Skeletal muscles (anterior view)

TABLE 1

Examples of Muscles

Name	Origin	Insertion	Action
deltoid	spine of scapula, clavical, acromial process	lateral surface of humerus	abducts arm
trapezius	occipital bone, 7th cervical, and all thoracic vertebrae	acromial process of clavicle and spine of scapula	draws scapula toward spinal column; rotates scapula to lift shoulder
latissimus dorsi	vertebrae, iliac crest	humerus	extends upper arm
triceps brachii	scapula	ulna	adducts upper arm
gluteus maximus	ilium, sacrum, coccyx sacrotuberous ligament	femur	extends thigh; rotates outward
gastrocnemius	femur	tarsal	extends foot; flexes lower leg
sternocleidomastoid	sternum, clavicle	temporal bone	flexes head (prayer muscle); rotates head toward opposite side
pectoralis major	clavicle, sternum, costal cartilage of ribs	humerus	flexes upper arm; adducts upper arm anteriorally; flexes supinated forearm
biceps brachii	scapula	radius	supinates forearm and hand
external oblique	lower eight ribs	iliac crest and pubis	compresses abdomen
flexor carpi radialis	humerus	second metacarpal	flexes hand; flexes forearm
vastus medialis	femur	tibia	extends leg
vastus lateralis	femur	tibia (patellar tendon)	extends leg
tibialis anterior	tibia	tarsal, metatarsal	flexes foot; inverts foot
serratus anterior	ribs	scapula	pulls shoulder forward; abducts and rotates it upward
intercostals	rib, lower border	rib, upper border	elevates ribs
sheath of rectus abdominus	ossa coxae	ribs, xiphoid process	compresses abdomen; flexes trunk
sartorius	anterior, superior iliac spines	tibia	adducts and flexes leg; permits crossing of legs

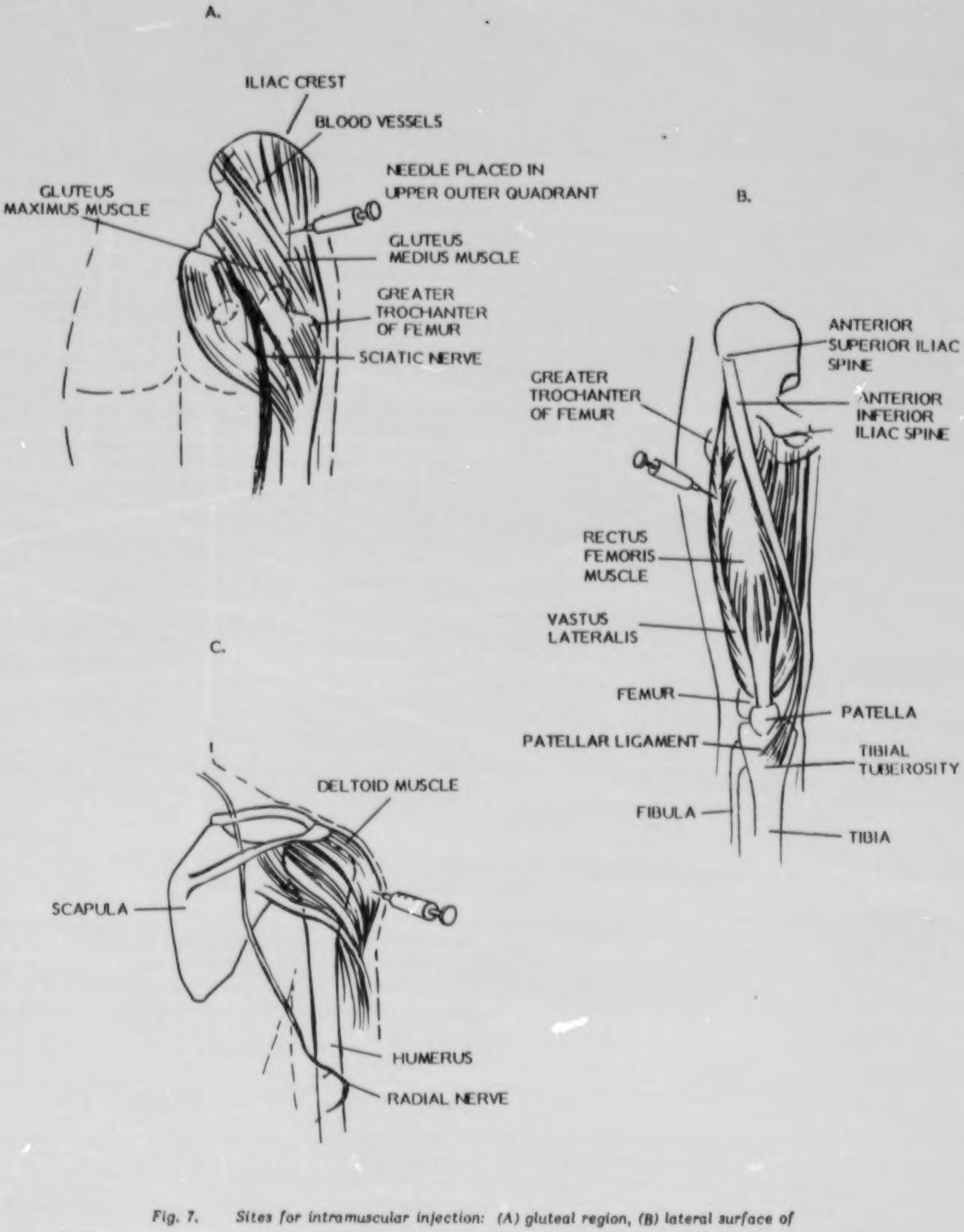

A.
ILIAC CREST
BLOOD VESSELS
NEEDLE PLACED IN
UPPER OUTER QUADRANT
GLUTEUS
MAXIMUS MUSCLE
GLUTEUS
MEDIUS MUSCLE
GREATER
TROCHANTER
OF FEMUR
SCIATIC NERVE
B.
ANTERIOR
SUPERIOR ILIAC
SPINE
GREATER
TROCHANTER
OF FEMUR
ANTERIOR
INFERIOR
ILIAC SPINE
RECTUS
FEMORIS
MUSCLE
VASTUS
LATERALIS
FEMUR
PATELLA
PATELLAR LIGAMENT
TIBIAL
TUBEROSITY
FIBULA
TIBIA
C.
DELTOID MUSCLE
SCAPULA
HUMERUS
RADIAL NERVE

Fig. 7. Sites for intramuscular injection: (A) gluteal region, (B) lateral surface of thigh, and (C) deltoid region

4

The Digestive System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the digestive system;*
2. *name and locate the parts of the digestive system;*
3. *name four types of teeth, and give the function and number of each kind;*
4. *discuss digestion in the stomach;*
5. *name the regions of the small intestine;*
6. *tell how the small intestine is modified to increase its absorption surface;*
7. *name digestive juices, and give the source and action of each;*
8. *discuss the function of the large intestine;*
9. *give the nondigestive functions of the liver;*
10. *explain the digestive role of the pancreas;*
11. *identify the omentum, peritoneum, and mesentery; and*
12. *identify disorders of the parts of the digestive tract.*

New Terms and Definitions

alimentary canal—the continuous tube that extends from the mouth to the anus. The process of digestion takes place in the alimentary canal.

bolus—a rounded mass of chewed food ready to be swallowed.

chyme—the material formed by the mixing and partial digestion of food in the stomach.

deciduous—shed at a given stage of development in a life cycle.

deglutition—the act of swallowing.

digestion—the changing of insoluble food materials to a soluble form by the action of enzymes.

emulsify—to break into small particles.

enzyme—protein substances produced in cells that bring about chemical reactions in digestion.

feces—body waste, residue of digestion, discharged from the anus.

heparin—compound produced in the liver which prevents blood from clotting.

lacteal—an intestinal lymph vessel.

mesentery—fold of peritoneum that encircles the small intestine and attaches it to the abdominal wall.

mesocolon—mesentery that connects the colon to the abdominal wall.

peristalsis—wavelike motion of the muscle tissue of the alimentary canal which moves the food through the digestive tube.

peritoneum—membrane that lines the abdominal cavity and covers the abdominal organs.

rugae—folds, particularly the folds of the mucous membrane lining the stomach.

sphincter—a circular muscle that constricts an opening.

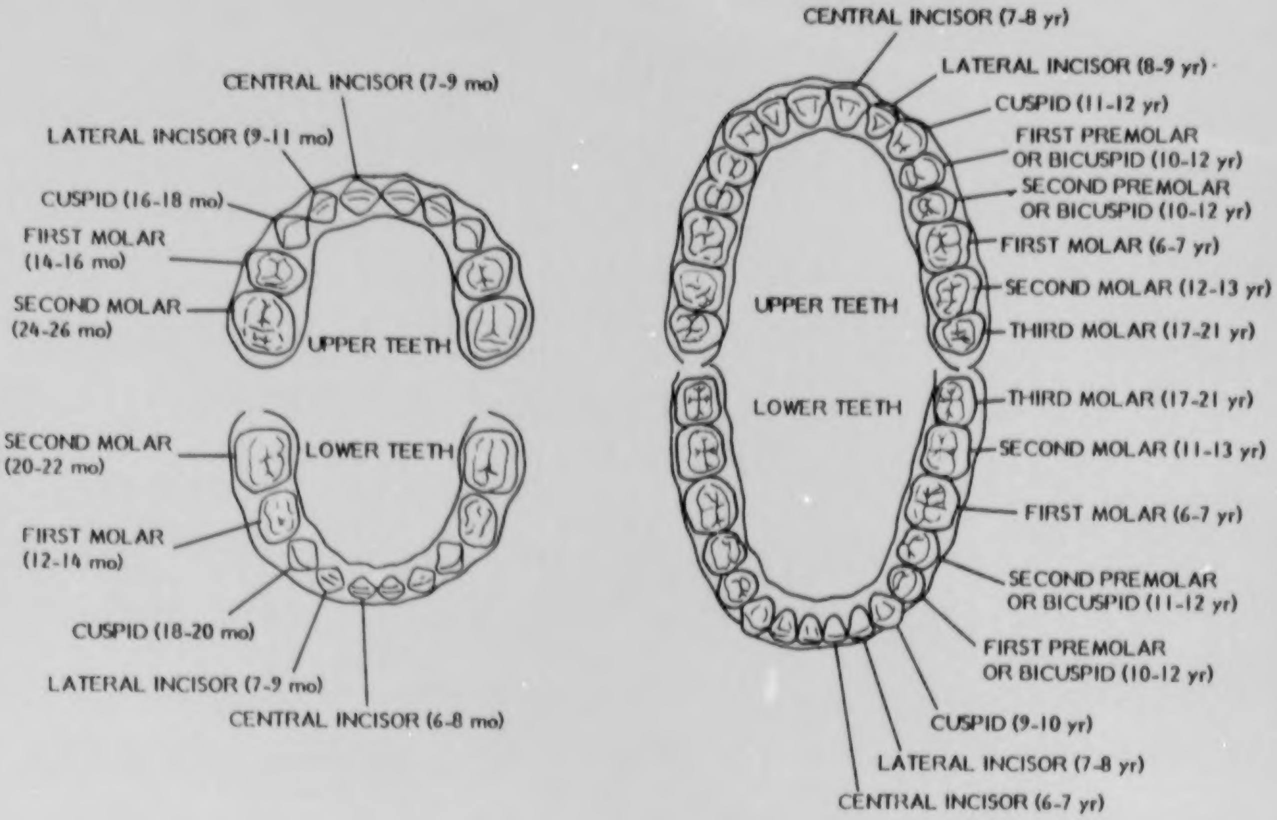

CENTRAL INCISOR (7-9 mo)
LATERAL INCISOR (9-11 mo)
CUSPID (16-18 mo)
FIRST MOLAR (14-16 mo)
SECOND MOLAR (24-26 mo)
UPPER TEETH
LOWER TEETH
SECOND MOLAR (20-22 mo)
FIRST MOLAR (12-14 mo)
CUSPID (18-20 mo)
LATERAL INCISOR (7-9 mo)
CENTRAL INCISOR (6-8 mo)
CENTRAL INCISOR (7-8 yr)
LATERAL INCISOR (8-9 yr)
CUSPID (11-12 yr)
FIRST PREMOLAR OR BICUSPID (10-12 yr)
SECOND PREMOLAR OR BICUSPID (10-12 yr)
FIRST MOLAR (6-7 yr)
SECOND MOLAR (12-13 yr)
THIRD MOLAR (17-21 yr)
UPPER TEETH
LOWER TEETH
THIRD MOLAR (17-21 yr)
SECOND MOLAR (11-13 yr)
FIRST MOLAR (6-7 yr)
SECOND PREMOLAR OR BICUSPID (11-12 yr)
FIRST PREMOLAR OR BICUSPID (10-12 yr)
CUSPID (9-10 yr)
LATERAL INCISOR (7-8 yr)
CENTRAL INCISOR (6-7 yr)

Fig. 1. Permanent and deciduous teeth

Types of Teeth	Number	Function
incisors	8	biting, cutting
canine	4	tearing, shredding
premolars	8	grinding, chewing
molars	12	grinding, chewing

Fig. 2. Types of teeth, number, and functions

umbilicus—impression or scar in the center of the abdomen where the umbilical cord was attached to the fetus; navel.

villi—short hairlike projections from the walls of the small intestine. Digested food is absorbed through villi.

Function of the Digestive System

The function of the digestive system is to change the insoluble foods we eat to a soluble form by the action of enzymes. The digestive system is usually divided into two areas, the alimentary canal and the accessory organs of digestion. The alimentary canal is a tube that extends from the mouth to the anus and includes the mouth, esophagus, stomach, small intestine, and large intestine. Its total length is about 30 feet. The accessory organs include the pancreas and liver. The secretions of these glands empty into the digestive tract to help bring about the digestion of food.

The Mouth

Digestion actually begins in the mouth where food is taken into the body. Here food is chewed and torn or ground into small pieces by the teeth and mixed with saliva.

There are two sets of teeth (fig. 1). The first or **deciduous** teeth are replaced by **permanent** teeth. There are twenty deciduous teeth, also called baby teeth or milk teeth because they appear in the first two years. These are replaced, beginning at about 6 or 7 years, with thirty-two permanent teeth. The teeth that erupt last are the third molars, or "wisdom teeth." The teeth are modified for specific functions. There are eight incisors for biting and cutting, four canine teeth for tearing and shredding, and eight premolars and twelve molars for grinding and chewing (fig. 2).

A common disease of teeth is dental **caries**, or tooth cavities. In **caries**, the hard outer layer of the tooth, or dentin, disintegrates and dissolves, leaving the inner parts of the tooth unprotected. If this condition is not repaired by filling the cavity to halt disintegration, the tooth may be lost.

As food is chewed, saliva from the salivary glands flows into the mouth. Saliva moistens and dissolves food particles making it easier to chew and to swallow. It also contains the enzyme ptyalin, which digests some starch and changes it to maltose, a simple sugar. Thus, digestion actually begins in the mouth.

There are three pairs of salivary glands: (1) the parotid glands, which are located below and in front of the ear; (2) the submandibular glands, which are found in the angle of the lower jaw; and (3) the sublingual glands, which are under the tongue. Saliva keeps the mouth moist at all times, but the flow is increased when food enters the mouth, or even when we see, smell, or think about attractive food.

The tongue is an important organ in the mouth. It guides food to and from the teeth and to the back of the throat for swallowing. It is, of course, used in speech, and it also contains taste buds that make it possible to determine flavors and that enhance the pleasure of eating. There are taste buds to identify sweet, sour, salt, and bitter. All flavors are derived from these four, or combinations of these, plus aromas detected by the olfactory senses of the nose. Before the taste buds can detect any flavor, the food must be in solution. Figure 3 shows the location of the four kinds of taste buds.

After food has been chewed and mixed with the saliva, it is formed into a rounded mass called a bolus before it is swallowed. The actual process of swallowing is called deglutition.

The roof of the mouth is divided into the anterior hard palate and posterior soft palate. In swallowing, the food mass is pushed to the hard palate by the tongue. Here the bolus is formed and pushed past the soft palate into the pharynx or throat.

The Pharynx or Throat

Three pairs of tonsils or lymph tissue are found in the throat. Their function is to protect the alimentary and respiratory tracts from invasion by pathogenic bacteria. Tonsilitis results when the tonsils themselves become infected.

The epiglottis is a piece of cartilage immediately behind the base of the tongue and above the opening into the respiratory tract, the glottis. The epiglottis is attached on one side, so it can move freely. During swallowing, the epiglottis closes over the glottis, so that food and liquids are routed into the esophagus rather than into the larynx of the respiratory tract. Violent coughing occurs when the epiglottis allows any food, liquid, or foreign particles to enter the larynx.

The Esophagus

After the bolus leaves the pharynx, it enters the esophagus (see fig. 4). This is a tubelike structure about 9 inches long that connects the pharynx to the stomach. It lies behind the trachea and passes through the diaphragm. Food is moved through the esophagus by gravity and by peristalsis. Peristalsis is the wavelike motion of muscle tissue of the entire alimentary canal that moves the food mass along. No digestion takes place in the esophagus.

The Stomach

From the esophagus food enters the stomach through the cardiac sphincter. A **sphincter** is a circular muscle that controls an opening. The cardiac sphincter opens and closes to regulate the flow of food from the esophagus and to prevent it from returning to the esophagus.

Stomachs are usually fishhook or J-shaped although they vary greatly both in size and shape. They also are capable of great changes in size and shape depending on their contents. The stomach is found below the diaphragm in the upper part of the abdominal cavity just under the liver. The stomach wall is comprised of three layers of muscle, each of which contracts in a different direction. The contraction of these muscles churns the food and mixes it with digestive juices secreted by the stomach.

The pyloric sphincter is between the stomach and small intestine and regulates the passage of food to the small intestine.

The inner layer of the stomach wall, called the gastric mucosa, is arranged in large folds (rugae). As the stomach fills with food, the rugae unfold to make it possible for it to distend as needed.

The stomach has four basic functions:

1. It receives swallowed food from the esophagus and passes it on to the small intestine.
2. It secretes gastric juice containing digestive enzymes and hydrochloric acid.
3. It churns food and gastric juice to begin digestion.
4. It absorbs water, ethyl alcohol, and some drugs.

Ethyl alcohol requires no digestion before it enters the bloodstream. The delivery of alcohol to the brain, liver, muscles, and other tissues begins within 2 minutes after it reaches the stomach. This explains why one may feel the effects of alcohol so quickly after ingestion.

Gastric juice is secreted by glands in the gastric mucosa. It contains the enzyme pepsin, sometimes called protease, which brings about the initial digestion of protein and changes it to proteoses and peptones. This reaction only takes place in an acid medium. The hydrochloric acid produced in the gastric glands not only provides the acid needed for pepsin to react, but also destroys many bacteria, particularly pathogens. The mucous lining of the stomach protects it from the hydrochloric acid. However, if for some reason the mucous coating is not present, a gastric ulcer may result.

Another enzyme, rennin, is also present in the gastric juice of babies and young children. It coagulates or begins the digestion of milk. This enzyme is not normally present in adults. A third enzyme, gastric lipase, digests some fats.

The food mixed with gastric juice is called **chyme**. After it has been churned and mixed in the stomach for 2 to 6 hours, it moves through the pyloric sphincter to the small intestine. Carbohydrates move most quickly, followed by proteins and finally fats.

The Small Intestine

The small intestine is a continuation of the alimentary canal. It is about 20 feet long (6 meters) and about an inch in diameter (2.5 centimeters). It lies in coils in the abdominal cavity and is divided roughly into three parts: the duodenum, which is about 10 inches long (25 centimeters); the jejunum, which is about 8 feet long (2.5 meters); and the ileum, which is about 12 feet long (3.6 meters).

The function of the small intestine is the completion of digestion and absorption of digested food. The organ is well adapted for its role. The great length increases the surface area available for the secretion of

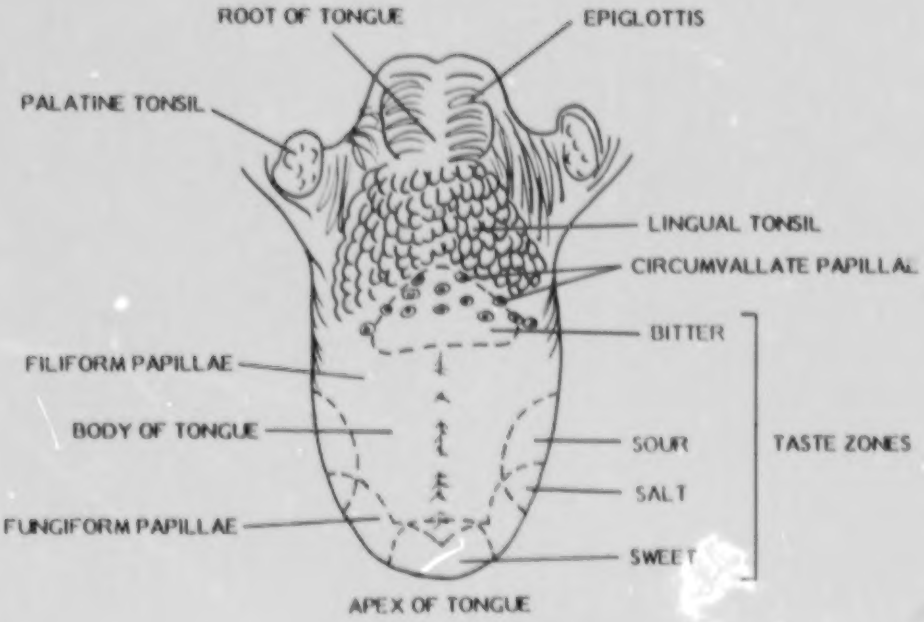

ROOT OF TONGUE
EPIGLOTTIS
PALATINE TONSIL
LINGUAL TONSIL
CIRCUMVALLATE PAPILLAE
BITTER
FILIFORM PAPILLAE
BODY OF TONGUE
SOUR
TASTE ZONES
SALT
FUNGIFORM PAPILLAE
SWEET
APEX OF TONGUE

Fig. 3. Taste areas

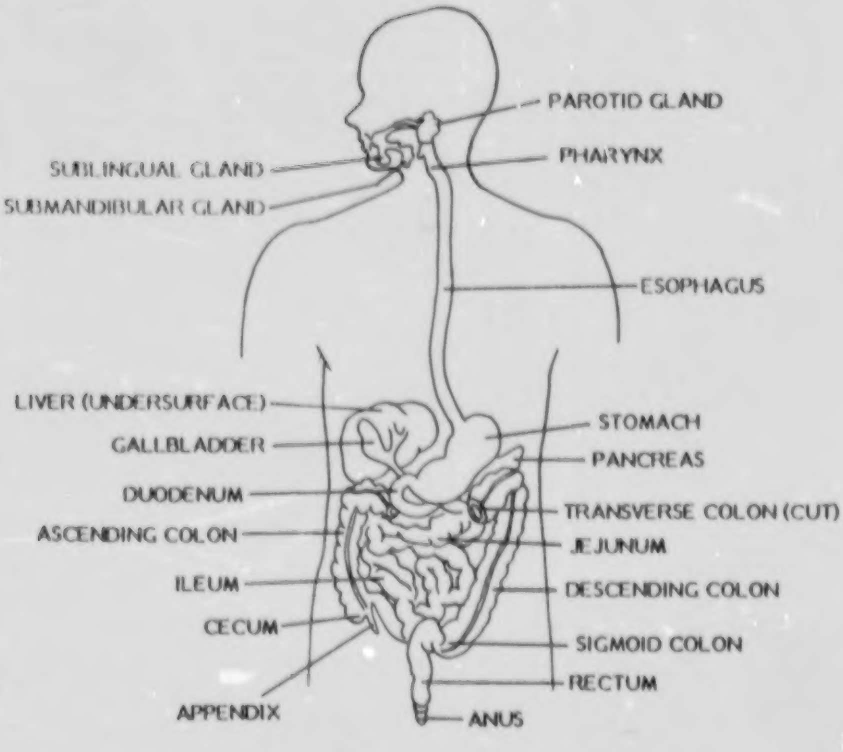

PAROTID GLAND
SUBLINGUAL GLAND
PHARYNX
SUBMANDIBULAR GLAND
ESOPHAGUS
LIVER (UNDERSURFACE)
STOMACH
GALLBLADDER
PANCREAS
DUODENUM
TRANSVERSE COLON (CUT)
ASCENDING COLON
JEJUNUM
ILEUM
DESCENDING COLON
CECUM
SIGMOID COLON
RECTUM
APPENDIX
ANUS

Fig. 4. Parts of the digestive system

digestive juices and for absorption. The surface area is further increased by the presence of villi. Villi are tiny fingerlike projections from the wall of the small intestine. They are present in such numbers that the inner lining of the small intestine has a velvety appearance. Each villus contains a venule, an arteriole, a capillary network, and a lacteal which is a lymphatic vessel. Digested food actually moves through the capillary walls of the villi and into the circulating blood. This is accomplished by diffusion and active transport.

The surface area of the small intestine is further increased by permanent folds in the lining. Some folds encircle the intestinal wall; some go only halfway around. This gives a spiral effect and slows the movement of chyme through the small intestine.

Food in the small intestine is acted upon by bile from the liver, by pancreatic juice from the pancreas, and by secretions of the intestinal glands found in the lining of the small intestine (fig. 5).

The Large Intestine

The water and undigested food enter the large intestine by way of the ileocecal valve. The large intestine is about 5 feet long (1.5 meters) and about 2.5 inches (6.5 cm) in diameter. The first 2 to 3 inches (5 to 8 cm) is the cecum, which extends in a blind pouch from the juncture of the ileum and then downward into the colon. Extending from the lower portion of the cecal pouch is the vermiform (worm-shaped) appendix. The appendix sometimes becomes infected or enlarged. This is called appendicitis. The function of the appendix is not understood.

The remainder of the colon is divided into the ascending, transverse, descending, and sigmoid colon. The ascending colon is on the right side of the abdominal cavity. The transverse colon, as the name implies, lies across the abdominal cavity, just under the umbilicus. The descending colon is found on the left side of the abdominal cavity and leads to the S-shaped or sigmoid colon. This in turn leads to the rectum, which holds feces by means of the anal sphincter until discharged from the body through the anus.

No digestion takes place in the large intestine. Its function is to remove water from the intestinal contents, secrete mucus, and eliminate feces. Also, nonpathogenic bacteria normally present in the large intestine aid in the synthesis of vitamin K and some of the B vitamins.

The Pancreas and Liver

The pancreas and liver are not part of the alimentary canal, but they release digestive juices into the small intestine by means of ducts. The pancreas lies just beneath the stomach in the curve of the duodenum. Pancreatic juice contains the enzymes amylase, which changes starch to disaccharide sugar; trypsin, which changes proteins to proteoses and polypeptides; and lipase, which changes fats to fatty acids, glycerols, and glycerides. The pancreas also contains endocrine (or ductless) glands called the islands of Langerhans. The glands secrete insulin, which is required for the metabolism of sugar, but do not secrete digestive enzymes. The endocrine and exocrine areas of the pancreas are not related in any way even though both are found in the pancreas.

The liver is the largest gland in the body. It consists of two principal lobes, and in adults it weighs about 4 pounds. It is located just below the diaphragm in the upper right region of the abdominal cavity. The liver secretes about a quart a day of the digestive juice bile. Bile enters the duodenum by means of the common bile duct. Here it emulsifies fats and prepares them for further digestion. But this is only one function of the liver. The liver also has many important nondigestive functions:

1. It destroys worn-out red blood cells and breaks down hemoglobin.
2. It manufactures heparin, which is an anticoagulant, as well as some other proteins contained in blood plasma, such as prothrombin, fibrinogen, and albumin.
3. It stores vitamins A, D, E, and K, as well as copper and iron.
4. The liver cells contain enzymes to break down and detoxify poisons. It stores some poisons that cannot be broken down, such as DDT.
5. It can change excess carbohydrates into glycogen or fat which can be stored; then it can transform the glycogen or fats into glucose in response to the body's needs.

DIGESTIVE JUICES AND ENZYMES

Digestive juices and enzymes	Source	Place of Action	Action of enzyme or digestive juice
Saliva	Salivary glands	Mouth	
Ptyalin (amylase)			Begins starch digestion
Gastric juice	Stomach	Stomach	
Pepsin (protease)			Begins protein digestion
Rennin (children)			Curdles milk
Hydrochloric acid			Kills some pathogenic bacteria Activates gastric enzymes
Bile (contains no enzymes)	Liver	Small intestine	Emulsifies fats
Pancreatic juice	Pancreas	Small intestine	
Trypsin			Acts on protein
Amylase			Acts on starch
Lipase			Acts on fats
Intestinal juice	Small intestine	Small intestine	
Peptidase			Acts on protein
Sucrase			Changes sucrose to simple sugar
Lactase			Changes lactose to simple sugar
Maltase			Changes maltose to simple sugar

Fig. 5. Digestive juices and enzymes

The Gall Bladder

The bile secreted by the liver is stored in the gall bladder (**gall** is another term for bile). The gall bladder is located along the under surface of the liver. Bile is released as needed and flows through the bile duct to the duodenum. Sometimes concretions or gallstones form in the gall bladder or bile duct. This condition is called cholelithiasis. Although much research has been done, currently the only treatment for gallstones is surgical removal. However, many patients with gallstones show no evidence of disease.

The Abdominal Cavity

The entire abdominal cavity is lined with a continuous membranous sheet called the peritoneum. The peritoneum also forms the outer coat of the various organs contained in the abdominal cavity. In this way the organs are secured and protected. A projection of the peritoneum folds over the small intestine and connects it to the posterior abdominal wall. This is called the mesentery. The large intestine is similarly secured to the posterior abdominal wall by another peritoneal projection, the mesocolon. Both the mesentery and the mesocolon contain blood and lymph vessels to help supply the large and small intestines.

Another structure in the abdominal cavity that protects the organs is the **greater omentum**. This is a continuation of the serosa (outside surface) of the stomach and duodenum. Suspended like a curtain from the greater curvature of the stomach, it covers the intestines and attaches to the transverse colon. The omentum contains some fat deposits. Its function is to prevent friction of the intestines, and it aids in localizing or warding off infections.

Diseases and Disorders

Diseases of the digestive tract are among those most often mentioned. The following list and brief descriptions are meant only to identify a few common maladies.

anorexia nervosa—loss of appetite without evidence of disease; thought to be a type of mental illness.

appendicitis—inflammation of the appendix.

cholecystitis—inflammation of the gall bladder.

cholelithiasis—presence of gallstones in the gall bladder or bile duct.

cirrhosis—a disease of the liver in which active liver cells are replaced by scar tissue.

colitis—inflammation of the colon and rectum.

constipation—abnormal delay in or infrequent bowel movement.

dental caries—tooth decay.

diarrhea—abnormally frequent, watery bowel movements.

dysentery—inflammation of the inner lining of the intestines, usually accompanied by diarrhea.

gastritis—inflammation of the lining of the stomach.

gingivitis—inflammation of the gums.

heartburn—burning sensation in the esophagus and cardiac end of the stomach, caused by gastric contents flowing back into the esophagus.

hemorrhoids—veins in the anal area that become enlarged and inflamed. Sometimes they are pushed outward on defecation.

hepatitis—inflammation of the liver.

hernia—protrusion of an organ through a body cavity that usually contains it. An example is an umbilical hernia in which abdominal organs protrude into the navel area of the abdominal wall.

jaundice—yellowish color of skin, whites of eyes, and mucous membrane, caused by an excess of bile pigments in the blood; associated with hepatitis.

mumps—viral infection of the salivary glands, most often of the parotid glands.

nausea—feeling of illness, unpleasant sensation usually preceding vomiting.

pancreatitis—inflammation of the pancreas.

peritonitis—inflammation of the peritoneum.

pyorrhea—inflammation of the tooth socket or peridontal area. It may cause degeneration of bone with loosening of the teeth.

stomatitis—inflammation of the lining of the mouth.

ulcer—an open lesion of the mucous membrane of the intestinal tract with sloughing of tissue and inflammation (gastric, peptic, or duodenal).

vomiting—reverse peristalsis resulting in ejection of stomach contents through the mouth.

5

The Blood and Cardiovascular System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the cardiovascular system;*
2. *discuss the functions of blood;*
3. *describe and give the function of the formed elements of blood;*
4. *give the role of platelets in the coagulation of blood;*
5. *discuss the significance of ABO blood types;*
6. *tell why the Rh factor is important in some pregnancies and transfusion;*
7. *describe the structure of the heart;*
8. *trace the course of the blood through the heart;*
9. *discuss the conduction system of the heart;*
10. *define pulse and blood pressure;*
11. *name the types of blood vessels;*
12. *describe the two major circuits formed by the blood vessels;*
13. *name and give the function of the components of the lymph system; and*
14. *identify common diseases of the blood and cardiovascular system.*

New Terms and Definitions

agglutination—clumping together of small particles.

antibody—protein substance in blood serum, developed in response to an antigen and reacting specifically with that antigen.

anticoagulant—substance which prevents the coagulation of blood.

antigen—any substance that stimulates the body to produce antibodies.

coagulation—process of clotting.

diapedesis—movement of leukocytes through the unbroken capillary wall.

electrocardiogram—recording of the electrical activity of the heart.

embolus—blood clot that has dislodged from its place of origin.

fibrinolysis—mechanism by which blood clots are dissolved.

hematology—the study of the blood.

hemorrhage—copious bleeding; undue loss of blood.

lymph—clear, watery fluid found in lymphatic vessels.

matrix—intercellular material of a tissue.

megakaryocyte—large bone marrow cell; cells from which platelets arise.

mitotic—pertaining to mitosis or cell division.

node—small, rounded mass of tissue; a protuberance or swelling.

phagocyte—a cell which engulfs and destroys bacteria and cellular debris.

plasma—liquid part of the blood that has been prevented from clotting by the addition of an anticoagulant.

reticuloendothelial—term for cells scattered throughout the body, such as the liver, spleen, tonsils, lymph nodes, and others, that ingest foreign particles.

serum—liquid portion of coagulated blood.

thrombus—blood clot.

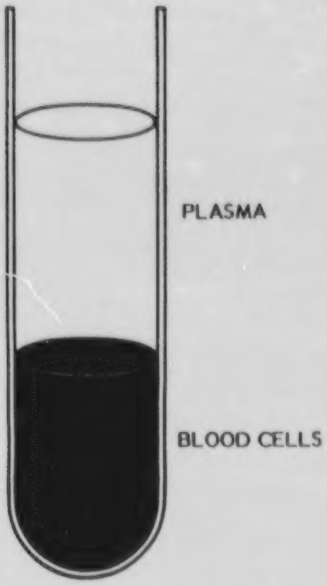


Fig. 1. Whole blood

Cells	Number (per cubic mm)	Diameter (microns)	Origin	Description	Function
erythrocytes	4,500,000- 5,500,000	7.5	red bone marrow	biconcave disc; lacks nucleus	transport O_2 and CO_2
leukocytes	7,500 (5,000-9,000)				
granulocytes					
neutrophiles		7-9	red bone	nucleus has marrow	phagocytosis; several lobes; fine cytoplasmic granules; stain lavender
eosinophiles		9-10	red bone	large, red cyto- marrow	phagocytize plasmic granules; bi-lobed nucleus
basophiles		7-9	red bone	large, purple marrow	liberate hista- cytoplasmic granules; nuclei are "S"-shaped
agranulocytes					
lymphocytes		6-8	lymphatic	single nucleus; tissue	synthesize anti- small amount of cytoplasm
monocytes		14-20	lymphatic	large central tissue	phagocytosis; nucleus; large amount of cytoplasm
thrombocytes	250,000- 500,000	2-4	red bone	irregular shape; marrow; lungs; spleen	necessary for no nucleus; stain purple

Fig. 2. Blood cells

Functions of Blood

Everyone knows that blood is important to life. Even primitive peoples correlated blood with health and loss of blood with death. Modern studies show that blood is as awesome as the ancients believed. The study of blood is called **hematology**, and scientists who study blood are hematologists.

Blood is a type of connective tissue. The liquid plasma is the matrix of intercellular space of the tissue, while the blood cells are the solid or formed elements. An easy way to visualize the parts of the blood is to allow a tube of whole blood, to which an anticoagulant has been added, to stand until the cells fall to the lower part of the tube. The yellowish liquid plasma remains on top (fig. 1).

Blood is a thick, sticky liquid in which cells are suspended. The average 150-pound person has about 10 pints of blood. It makes up about 8 percent of our body weight. Blood is about 92 percent water, but many important things are either dissolved or suspended in it. Soluble components include three plasma proteins: albumins, which maintain blood viscosity; globulins, which are antibodies produced by leukocytes; and fibrinogen, which is necessary for clot formation. Other soluble components are nutrients, such as glucose, lipids, and amino acids, and organic wastes, such as urea, uric acid, ammonia salts, and creatine. Inorganic salts in the plasma maintain a normal pH balance. Small quantities of oxygen and carbon dioxide are carried in the blood plasma, though larger quantities are carried by the hemoglobin. Regulatory substances such as enzymes and hormones are dissolved in the plasma, and thus transported from their source to all parts of the body.

If whole blood is allowed to clot, the liquid that separates from the solid constituents is serum. Serum differs from plasma in that it contains the clotting elements of blood.

One important function of the blood is transportation. It carries oxygen and nutrients from the digestive and respiratory systems and delivers them to each cell. It also transports waste products of metabolism from the cells to the excretory organs. This includes carbon dioxide from the cells to the lungs, and wastes from the cells to the kidneys. It transports hormones produced by the endocrine glands from their production site to the cells and tissues.

Second, the blood helps regulate and equalize body temperature by distributing heat to all body parts. The third main function of the blood is to defend the body against invasion by bacteria and viruses. White blood cells are able to engulf and destroy pathogens.

Blood Cells

The formed elements in the blood are the cells—the red cells (erythrocytes), the white cells (leukocytes), and the platelets (thrombocytes) (fig. 2). The erythrocytes are most numerous, averaging 4.5 million per cubic millimeter in females and 5.5 million per cubic millimeter in males. In adults, the average total number of red blood cells is about 35 trillion (35,000,000,000,000). Of course, such a figure is not important to remember, but it is important to understand that each person has a great many red blood cells.

The total number of red blood cells varies with age and activity. Infants have a higher red blood cell count than children and adults. The number is increased with activity and decreased during sleep. The number is also increased at higher altitudes. These factors must be taken into account in determining normal numbers of cells.

Red blood cells are produced in the red marrow of bones by specialized cells. They go through several stages of development before they mature and are liberated into the circulating blood as needed. Unlike most other body cells, mature blood cells do not reproduce by mitotic cell division. Immature erythrocytes have a nucleus, but the nucleus is extruded before they enter the bloodstream. The nucleus is not needed for cell division, and the cellular space is used for the cell's transport activities.

Immature red blood cells are spheroid in shape, but after the nucleus is lost, the cell becomes a biconcave disc shape. This shape increases surface area while decreasing the amount of space needed for each cell. Red blood cells are only about 7 to 7.5 microns (1/100,000 meter) in diameter. This small size and their shape makes it possible for them to move through the intercellular spaces of the capillary walls.

Red blood cells contain hemoglobin, which gives blood its characteristic bright red color. The hemoglobin molecule has been studied extensively. It has been found to consist of two parts: **globin,** which is a protein molecule, combined with four molecules of a pigment called **heme.** Each hemoglobin molecule also contains four iron atoms. Each iron atom can combine with a molecule of oxygen. A single erythrocyte contains about 280 million molecules. Thus, a single erythrocyte can combine with 1.12 billion molecules of oxygen. Again, the figures are unimportant except to emphasize the unique combining power of hemoglobin and oxygen.

Red blood cells survive in the circulating blood for an average of only 120 days. Then they break apart, and the pieces are engulfed and destroyed by the reticuloendothelial cells of the liver and spleen. In the cellular breakdown, iron is released from the hemoglobin, and compounds such as bilirubin are formed. Iron is stored in the liver until it is transported to the bone marrow where it is used in building more red blood cells. The bilirubin is excreted in the bile.

The function of red blood cells is the transportation of oxygen and carbon dioxide. As the blood passes through the lungs, oxygen combines with hemoglobin and is transported to all the tissues. In the tissues, oxygen is released. Carbon dioxide from the tissues combines with the globin portion of the hemoglobin molecule and is taken back to the lungs. There the carbon dioxide is released and excreted by the lungs.

Anemia is a term that refers to a deficiency of erythrocytes or of hemoglobin. There are many kinds of anemia with many different causes. It is not a disease, but a symptom of many different diseases. Anemia in general causes the patient to feel tired and weak because the oxygen-carrying capacity of the blood is diminished. To determine the amount of red blood cells present, laboratory tests are done.

White blood cells or leukocytes (see fig. 2) are classified by the presence or absence of granules in the cytoplasm. Cells which contain such granules are called **granulocytes.** There are three separate kinds of these, named for their staining reactions. **Neutrophiles** have fine cytoplasmic granules that stain lavender. The nuclei have several lobes, so one name for these cells is polymorphonuclear leukocytes, shortened to "polys." **Eosinophiles** are another type of granulocyte. They have large cytoplasmic granules that stain red. Their nuclei are bilobed. **Basophiles** have large cytoplasmic granules than stain purple. The nuclei of basophiles are usually S-shaped. Granulocytes are formed in the red bone marrow.

Agranulocytes are leukocytes that lack granules in the cytoplasm. They are formed in bone marrow and lymphoid tissue. There are two kinds of agranulocytes, lymphocytes and monocytes. **Lymphocytes** are small, and have a large, round central nucleus and a small amount of cytoplasm. **Monocytes** are larger. They also have a large central nucleus, but it is surrounded by a large amount of cytoplasm (fig. 3).

Blood cells are stained to study their morphology and for differentiation. They are most often stained with Wright's stain, which is a polychrome stain. It contains methylene blue and eosin. It is differential in that the granules in neutrophiles and basophiles take up the blue (basic) stain. The granules of eosinophiles take up the red (acidic) dye, eosin.

The overall function of leukocytes is to combat pathogenic organisms that have invaded the body. They are capable of ameboid motion. Thus, they can move between the intercellular spaces of the capillaries into the tissues and migrate to the invading microorganisms. There they engulf and destroy them. The movement through the capillary walls is called **diapedesis** (fig. 4). **Phagocytosis** is the term which means to engulf and destroy microorganisms. Neutrophiles are most active in phagocytosis (fig. 5). They also produce the enzyme lysozyme (muramidase) which destroys some bacteria.

Monocytes also phagocytize pathogenic microorganisms, and they engulf the remnants of dead cells following an infection. Eosinophiles are thought to detoxify the proteins that accumulate from allergic reactions. Also, if cells are damaged from parasitic invasions (such as trichinosis), eosinophiles destroy the cellular debris. Basophiles contain heparin, an anticoagulant. It is thought that heparin plays a role in preventing the coagulation of blood in the blood vessels, and facilitates blood clot absorption. Lymphocytes are important in

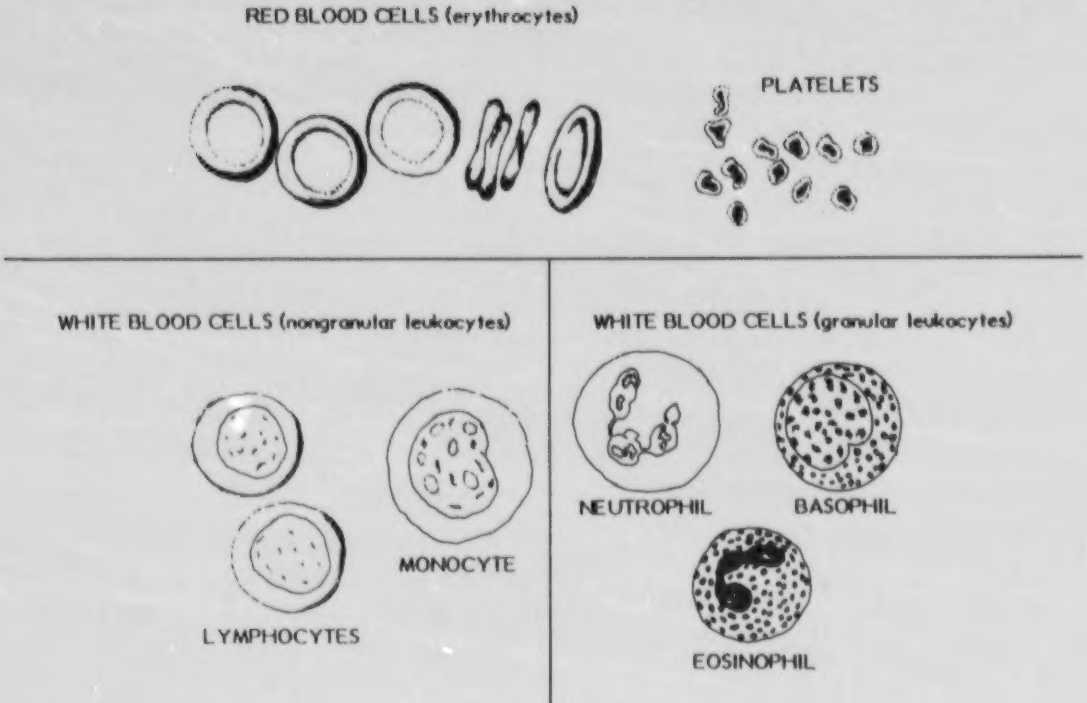

RED BLOOD CELLS (erythrocytes)
PLATELETS
WHITE BLOOD CELLS (nongranular leukocytes)
WHITE BLOOD CELLS (granular leukocytes)
LYMPHOCYTES
MONOCYTE
NEUTROPHIL
BASOPHIL
EOSINOPHIL

Fig. 3. Blood cells

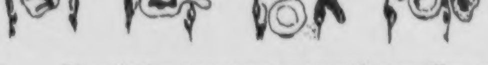


Fig. 4. Diapedesis—leukocyte penetrating capillary wall

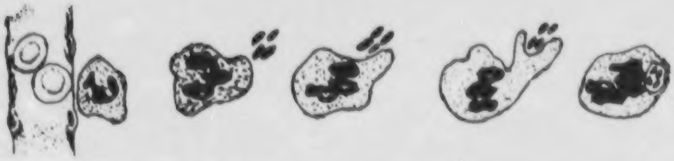


Fig. 5. Phagocytosis—leukocyte engulfing bacteria

the production of antibodies and in immune responses.

In studying the blood, a **differential** white blood cell count is done to determine the percentage of each kind of leukocyte. Of course, numbers can vary, but an average number is as follows:

Lymphocytes	20 to 25 percent
Monocytes	3 to 7 percent
Neutrophiles	60 to 70 percent
Eosinophiles	2 to 4 percent
Basophiles	0 to 2 percent

The differential is a valuable diagnostic tool because numbers of the various kinds of leukocytes increase or decrease in specific diseases. For example, in any bacterial infection, such as pneumonia or staphylococcal infections, the number of neutrophiles rises. In allergic reactions or parasitic infestations, the number of eosinophiles increases. Monocytes are increased in some chronic infections. There are many other differential counts that indicate specific disease conditions.

Platelets, or thrombocytes, are really fragments of large cells formed in red bone marrow, the megakaryocytes. These cells break apart; then the fragments are enclosed in part of the cell membrane to form platelets. These small cells are nonnucleated. They are vital to the process of coagulation of blood. A platelet count is a useful procedure in diagnosing some types of anemia.

Platelets tend to adhere to any uneven spot, such as the cut edge of a blood vessel, a rough spot in the normally smooth lining of a blood vessel, or even the cholesterol lipid deposits of atherosclerosis in blood vessels. They clump together and liberate the enzymes that initiate the clotting process.

In the clotting process, first the thrombocytes disintegrate, releasing thromboplastinogenase. This enzyme causes thromboplastinogen to be transformed to thromboplastin. The thromboplastin in the presence of calcium ions brings about the conversion of prothrombin to thrombin. Fibrinogen in the presence of thrombin is converted to fibrin. Fibrin is structured in fine threads which are insoluble and which form a network that traps red blood cells and forms a clot. The following series of word equations outlines the process:

thromboplastinogenase + thromboplastinogen → thromboplastin
calcium ions
thromboplastin + prothrombin → thrombin
thrombin + fibrinogen → fibrin
fibrin + red blood cells → clot

A summary of this complex process begins with the disintegration of platelets and the release of an enzyme that initiates the process of coagulation. The end product is fibrin, which is in the form of fine threads. These threads form a network that enmeshes red blood cells and forms a clot.

The various components for this process are formed in different parts of the body. Prothrombin and fibrinogen are synthesized in the liver. Vitamin K is required to bring about this synthesis. Some vitamin K is produced by bacteria in the intestine, and some is absorbed from ingested foods. Thromboplastinogen is a normal component of plasma. Thromboplastinogenase comes from blood platelets and from damaged tissue. Platelets disintegrate when blood comes in contact with a foreign surface unless the surface is totally smooth.

It is thought that tiny vessels of the circulatory system are constantly rupturing and that clots immediately form to stop bleeding. Thus, two opposing processes, fibrinolysis (which results in bleeding) and clot formation (to stop bleeding), go on all the time. Antithrombins are the agents that prevent clotting by inactivating thrombin, thus inhibiting the conversion of fibrinogen to fibrin. Two antithrombins are heparin, found in the liver and basophiles, and coumarin compounds, which inhibit the liver's use of vitamin K.

Antigens and Antibodies

There are other important factors in the blood. Among these are the antigens and antibodies that determine our blood type. An **antigen** is a substance that reacts with its specific antibody. Antigens are named for the type of antigen-antibody reaction they may bring about. The antigens on the surface of red blood cells are called agglutinogens.

Antibodies are protein substances in the plasma that react with their specific antigen. Thus, agglutinogens (antigens) will react with agglutinins (antibodies) to bring about agglutination. There are many different kinds of antigen-antibody reactions.

There are two kinds of agglutinogens that may be found on the surface of human red blood cells, called A and B. An individual may have either A or B, both A and B, or neither A nor B. A person's blood group or type is determined by the presence or absence of these A and B antigens.

If a person has A agglutinogens on the red blood cells, then she/he will also have corresponding antibodies called Anti-B agglutinins in the plasma. Persons with B agglutinogens will have Anti-A agglutinins. Those with both A and B agglutinogens will have no agglutinins; those with neither A nor B agglutinogens will have both Anti-A and Anti-B agglutinins. Plasma could never contain antibodies against the antigens on its own red blood cells. If so, the antigen and antibody reaction would bring about the agglutination of the person's own red blood cells. Table 1 shows the antigens and antibodies present in the various blood types.

Blood Types and the Rh Factor

Blood types are important in blood transfusion because, of course, if donor blood is of a type containing antigens and/or antibodies of a type different from that of a recipient, the red blood cells will agglutinate and cause severe reaction or even death. You will note that blood group O has no antigens. It is called the "universal donor" because theoretically the blood would not react with any cells in transfusion. In actual practice, patients are almost always transfused with their own type of blood. The Anti-A and Anti-B antibodies in the serum and other factors in the blood could cause an undesirable reaction (fig. 6).

Blood types are hereditary and do not change during one's lifetime. The pattern of inheritance is predictable. It is possible, by determining blood types, to know whether a given person **could be** the parent of a particular child, but not that she or he **is** the parent. Further research of blood factors may provide definite proof of parentage.

The percentage of a given blood type in various ethnic groups varies. In the United States, the following percentages have been found: Type O, 47 percent; Type A, 41 percent; Type B, 10 percent; and Type AB, 4 percent.

Another blood factor that may cause cells to agglutinate is the **Rh factor**. It gets its name from Rhesus monkeys, the only animals in which it is found besides humans. Only 85 percent of the U.S. population has this factor. They are said to be Rh-positive. Those who lack the factor are Rh-negative. Rh antigens are on the surface of the red blood cells as well as the A and B antigens. Thus, a person can be Type A, B, AB, or O and also Rh-positive or Rh-negative.

The Rh factor is of little importance except in the pregnancy of Rh-negative persons, or if they receive blood transfusions. If an Rh-negative individual receives a blood transfusion from an Rh-positive donor, the body is stimulated to produce specific anti-Rh antibodies. These remain in the blood. If the patient receives further transfusions of Rh-positive blood, the Rh antigen on the donor's red blood cells and the Rh antibody in the patient's blood will react, causing the red blood cells to agglutinate with serious consequences or even death.

To avoid this problem, Rh determinations are done prior to transfusion with whole blood, and Rh-negative patients are given only Rh-negative blood. Thus, there can be no antigens to stimulate the production of antibodies.

The inheritance of Rh types follows genetic patterns. The child of an Rh-negative mother and an Rh-positive father could be either Rh-positive or Rh-negative. If the child is Rh-positive, it is possible for Rh antigens to cross the placental barrier during pregnancy and cause the Rh-negative mother to produce Rh antibodies. In a subsequent pregnancy with an Rh-positive fetus, an antigen-antibody reaction between the infant's red blood cells and the anti-Rh antibodies in the mother's blood could cause the red blood cells of the infant to break down or hemolyze, releasing hemoglobin in the baby's blood. This may cause the baby to be anemic. Further damage may be caused if the disintegrating red blood cells occlude the blood vessels. This is called **erythroblastosis fetalis** and is treated by giving the baby many small transfusions of Rh-negative blood to replace the damaged blood (fig. 7).

TABLE 1

ABO Blood Types

Blood group	Agglutinogen on red blood cells	Agglutinin in serum	Cells agglutinated
A	A	Anti-B	B, AB, O
B	B	Anti-A	A, AB, O
AB	A, B	None	A, B, AB, O
O	None	Anti-A, Anti-B	None

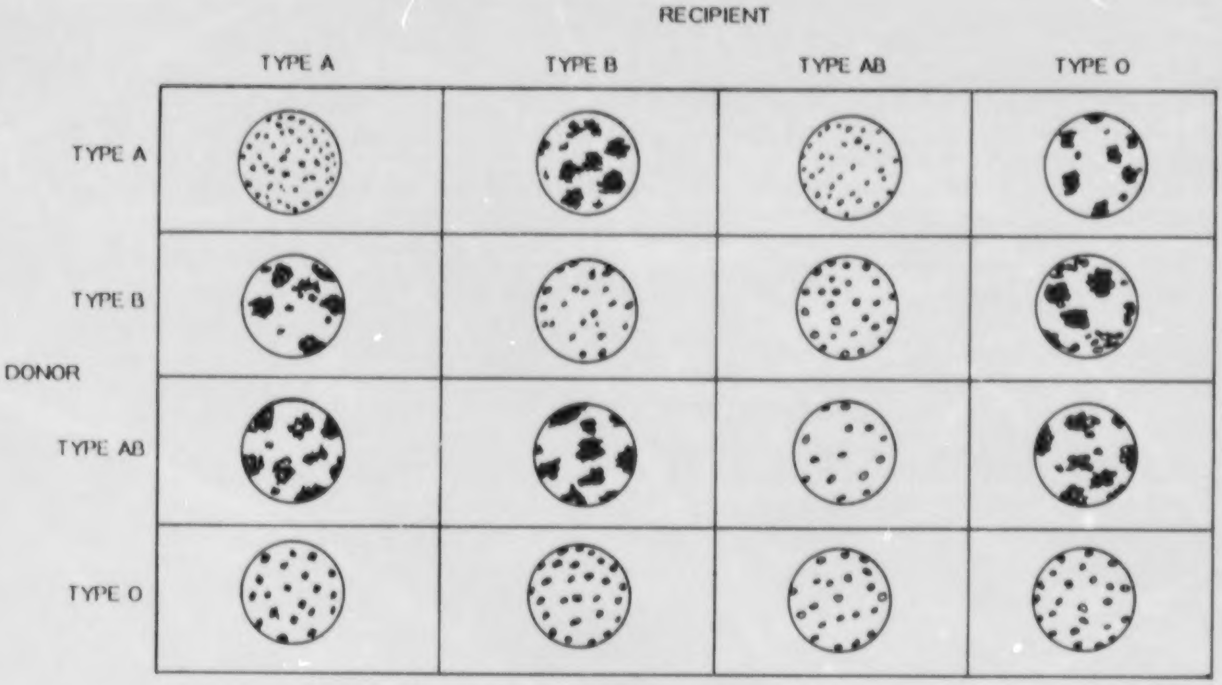
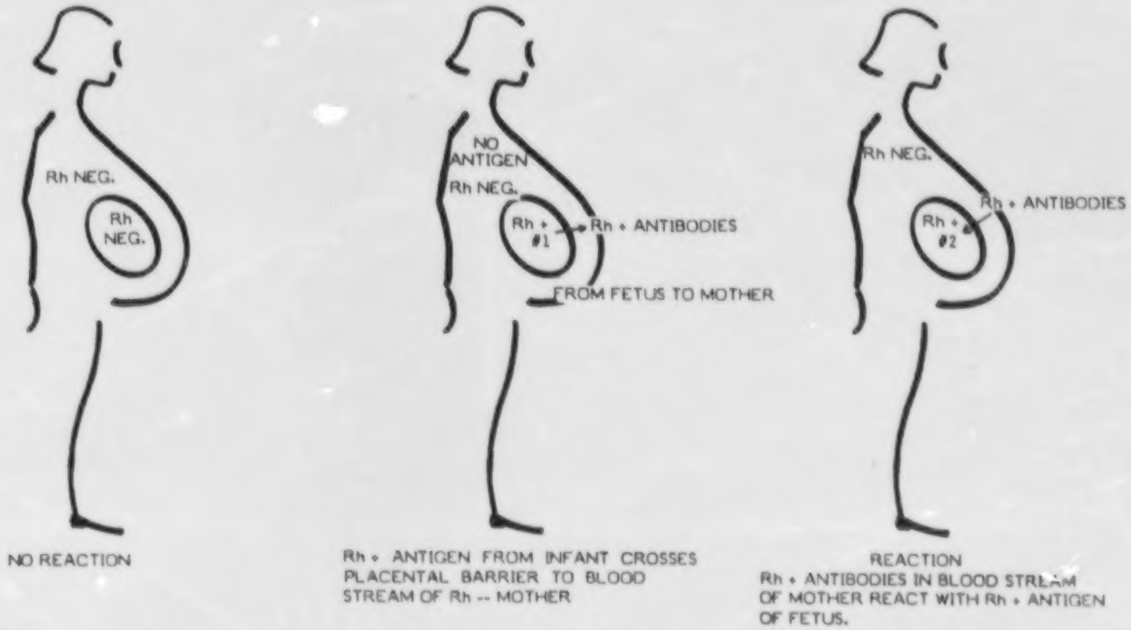

RECIPIENT
TYPE A
TYPE B
TYPE AB
TYPE O
DONOR
TYPE A
TYPE B
TYPE AB
TYPE O

Fig. 6. Reactions of ABO blood groups in cross matching prior to transfusion


Rh NEG.
Rh NEG.
NO ANTIGEN
Rh NEG.
Rh + #1
Rh + ANTIBODIES
FROM FETUS TO MOTHER
Rh NEG.
Rh + ANTIBODIES
Rh + #2

NO REACTION

Rh + ANTIGEN FROM INFANT CROSSES PLACENTAL BARRIER TO BLOOD STREAM OF Rh -- MOTHER

REACTION
Rh + ANTIBODIES IN BLOOD STREAM OF MOTHER REACT WITH Rh + ANTIGEN OF FETUS.

Fig. 7. Rh factor in pregnancy

Currently, if an Rh-negative mother delivers an Rh-positive baby but has no anti-Rh antibodies, she is given anti-Rh immune globulin during the first 72 hours after delivery. These antibodies react with the fetal antigens in the mother's blood, if any, so she will not produce anti-Rh antibodies. Then, if a second pregnancy with an Rh-positive fetus occurs, there will be no Rh-positive antibodies present to cause a reaction.

Although Rh factors must be determined to provide adequate care of both mother and child, the actual numbers involved are small.

Structure of the Cardiovascular System

The cardiovascular system is made up of the heart and blood vessels. The heart is the organ that moves blood through the circulatory system and thus to and from each part of the body. It is located in the chest cavity. The top of the heart is at a point between the second and third ribs. The apex is between the fifth and sixth ribs and points to the left. About one-third of the mass of the heart lies to the right of the sternum, and two-thirds lies to the left. The heart, of course, varies in size and even shape among individuals, but it is a hollow, muscular, cone-shaped organ. It is about the size of the individual's fist. An average weight for the heart of an adult male is about one pound.

The heart has four chambers. The two upper chambers are called atria or auricles. The lower chambers are ventricles. The right and left sides are divided by a septum and have no communication.

The heart wall is made up of three distinct layers: (1) the outer layer (epicardium), (2) the middle layer (myocardium), and (3) the endocardium, which is a thin membrane that lines the chambers of the heart, covers the valves, and is continuous with the lining of the major blood vessels that enter the heart. The myocardium is made of cardiac muscle. The heartbeat is the result of the rhythmic contraction and relaxation of the myocardium. The pericardium is a tough, but loose-fitting sac that covers and protects the heart.

There are four valves in the heart to prevent backflow of blood. The semilunar valves keep the blood from reentering the heart. The pulmonary semilunar valve prevents the backflow of blood into the right ventricle as it leaves by way of the pulmonary artery. The aortic semilunar valve prevents the backflow of blood from the aorta into the left ventricle. The valve between the right atrium and right ventricle is the tricuspid valve. It has three flaps or cusps, thus the name "tricuspid." The valve between the left atrium and left ventricle is the bicuspid or mitral valve. These two valves are also called auricular-ventricular valves.

The blood returns from the body by means of the superior vena cava (carrying carbon dioxide) and enters the right atrium. It leaves the right atrium and falls through the tricuspid valve to the right ventricle. There it passes through the pulmonic (semilunar) valve to the pulmonary artery (which is the only **artery** that carries carbon-dioxide-laden blood) and to the lungs. In the lungs carbon dioxide is given off, and the blood is replenished with oxygen. The pulmonary veins (which are the only **veins** that carry freshly oxygenated blood) return oxygenated blood from the lungs to the heart. It enters the left atrium and passes through the bicuspid (mitral) valve into the left ventricle. Then it passes through the aortic (semilunar) valve to the aorta to be distributed throughout the body (fig. 8).

The heart must pump blood to every part of the body to meet the metabolic needs of the cells. The atria contract, forcing blood into the ventricles. At the end of the atrial contraction, the ventricles contract, forcing the blood out of the ventricles. Blood from the right ventricle is forced into the pulmonary artery and thence to the lungs. Blood from the left ventricle is forced into the aorta.

The heart has a built-in regulating system called the **conduction system.** It is composed of cardiac muscle modified to conduct impulses. Heart action is automatic; that is, it is independent of outside impulses to initiate its contraction.

Three structures make up the conduction system. First is the **sinoatrial (SA) node,** located in the upper wall of the right atrium. It is called the pacemaker because it initiates the heartbeat and sets its rate.

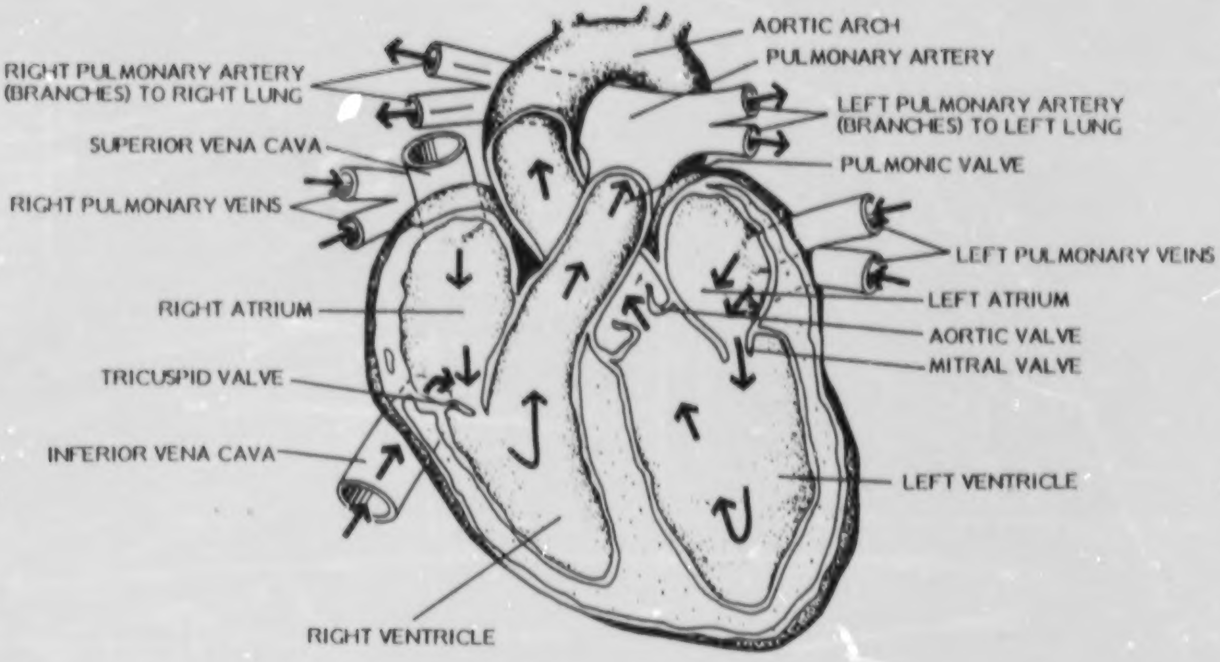

AORTIC ARCH
PULMONARY ARTERY
RIGHT PULMONARY ARTERY (BRANCHES) TO RIGHT LUNG
LEFT PULMONARY ARTERY (BRANCHES) TO LEFT LUNG
SUPERIOR VENA CAVA
PULMONIC VALVE
RIGHT PULMONARY VEINS
LEFT PULMONARY VEINS
LEFT ATRIUM
RIGHT ATRIUM
AORTIC VALVE
MITRAL VALVE
TRICUSPID VALVE
INFERIOR VENA CAVA
LEFT VENTRICLE
RIGHT VENTRICLE

Fig. 8. The heart

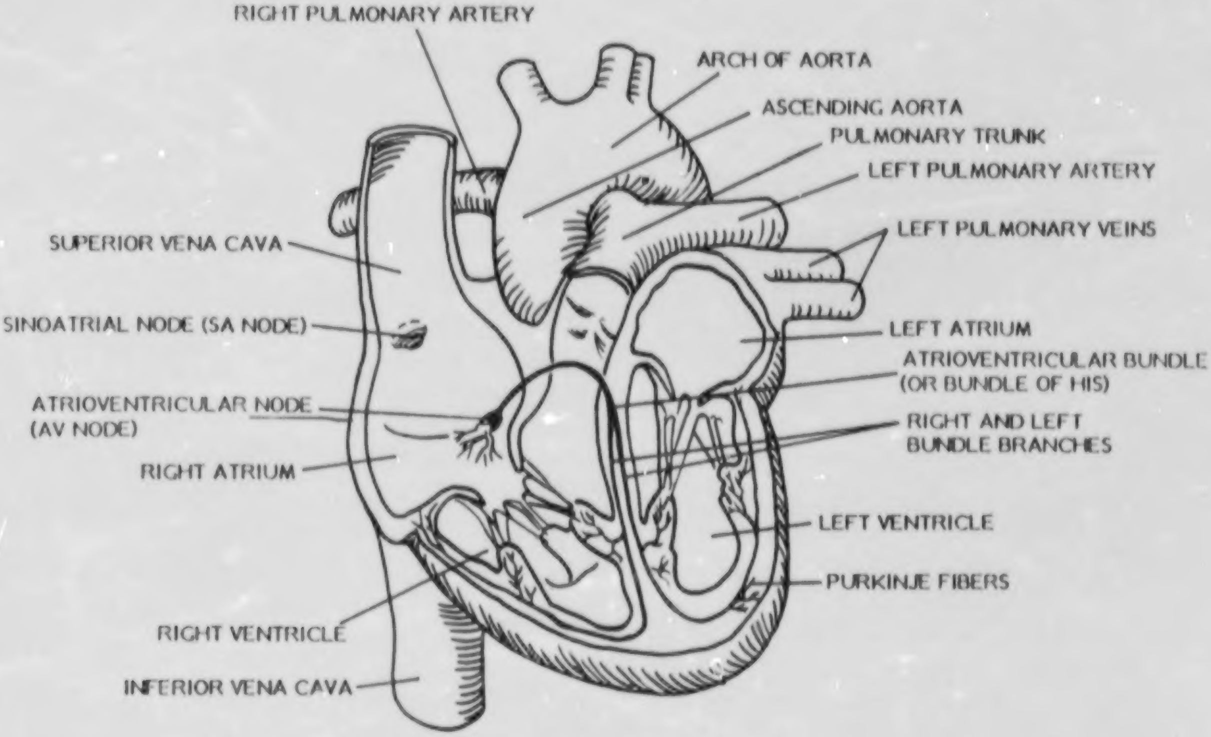

RIGHT PULMONARY ARTERY
ARCH OF AORTA
ASCENDING AORTA
PULMONARY TRUNK
LEFT PULMONARY ARTERY
LEFT PULMONARY VEINS
SUPERIOR VENA CAVA
SINOATRIAL NODE (SA NODE)
LEFT ATRIUM
ATRIOVENTRICULAR BUNDLE (OR BUNDLE OF HIS)
ATRIOVENTRICULAR NODE (AV NODE)
RIGHT AND LEFT BUNDLE BRANCHES
RIGHT ATRIUM
LEFT VENTRICLE
PURKINJE FIBERS
RIGHT VENTRICLE
INFERIOR VENA CAVA

Fig. 9. The conducting system of the heart

These impulses initiated by the SA node travel through the muscle fibers of both atria, causing them to contract.

The **atrioventricular (AV) node**, located in the lower part of the right atrial wall, is stimulated next. This impulse is transmitted to the **atrioventricular bundle** (AV bundle), also called the bundle of His. This is a group of specialized cardiac muscle fibers that are adapted for conduction of impulses. The AV bundle branches to go down each side of the septum which divides the right and left ventricles. Each branch divides to form a network called the Purkinge network. Thus, the walls of the ventricles are supplied with conducting fibers.

As an impulse originates in the SA node, the atria contract, almost simultaneously, forcing blood into the ventricles. The impulse reaches the AV node at about the conclusion of atrial contraction. Then the impulse travels over the AV bundle (connecting link) and causes ventricles to contract, thus forcing blood from the left ventricle into the aorta, and the right ventricle to the pulmonary artery (fig. 9).

The tiny electrical impulses generated by the heart's conduction system can be recorded from the surface of the skin. Such a record is an electrocardiogram. It is of great clinical significance because it records any variations in heart muscle action. Persons skilled in the interpretation of electrocardiograms can thus determine disease and follow the patient's progress. The machine that makes the recording of the electrical variation in the action of heart muscles is an electrocardiograph.

Neural control of heart activity is maintained by the autonomic nervous system.

Pulse is the waves of increased pressure in arteries as a result of ventricular contraction. Perhaps a better definition is the alternate expansion and recoil of an artery. The **pulse rate** is actually the rate at which the heart beats. It is affected by body size, muscular activity, emotional disturbance, infections, and endocrine secretions. In general, the smaller the person, the faster the pulse rate. Newborn babies have a pulse rate of 120 to 140, while in normal adults the rate is around 70 to 82.

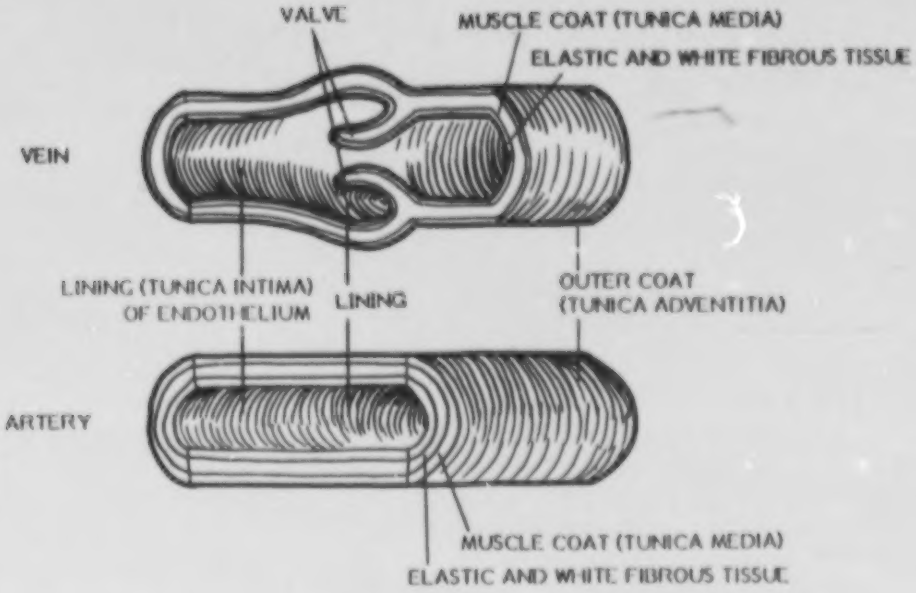
The pulse rate is useful in determining disease. One of the most commonly performed procedures in the care of the ill is a determination of vital signs—that is, temperature, pulse, respiration, and blood pressure. Most often, the pulse rate is counted at the radial artery of the wrist. Sometimes this is not convenient so other sites are used, such as the carotid artery of the throat, the temporal artery of the head, the popliteal artery at the knee, and the dorsalis pedis at the ankle.

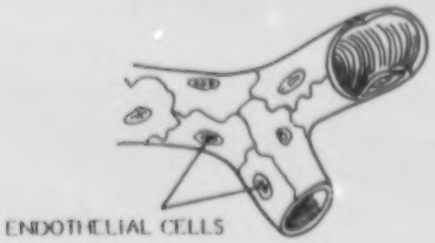
Blood pressure refers to the pressure the blood exerts on the inside walls of the blood vessels. It is measured in millimeters of mercury. The pressure during the contraction of the heart muscle, or systole, is the systolic blood pressure. The pressure which occurs during the relaxation of the heart muscle, or diastole, is the diastolic blood pressure. The normals of blood pressure vary widely. Also, as is true of pulse rate, blood pressure varies with age, activity, and emotional disturbance. Blood pressure is recorded as systolic over diastolic pressures. Thus, a systolic pressure of 120 millimeters of mercury and a diastolic pressure of 75 millimeters is recorded as 120/75. An abnormal increase in either the systolic or the diastolic pressure is termed **high blood pressure.**

Blood is transported to every part of the body by the action of the heart as it pumps the blood through the network of the vascular system. The arteries carry blood away from the heart. Those leaving the heart are the largest. They branch into smaller arteries and finally into even smaller vessels called arterioles. These continue to branch into smaller vessels until they branch into the capillaries. The veins return the blood to the heart. They also branch from large veins at the heart to venules, which finally branch into the capillaries. Thus, the cardiovascular system is a closed system. The heart pumps the blood through the arteries and arterioles to the capillaries, to the venules, and then to the veins through which the blood returns to the heart.

The force of the heartbeat forces the blood through the arteries. To cause the blood to return to the heart, the inner lining of the veins forms valves that permit the blood to flow toward the heart but prevent backflow. Also, the movement of muscles helps to cause blood to flow back to the heart (fig. 10).

There are two major circuits formed by the blood vessels—pulmonary and systemic.


VALVE
MUSCLE COAT (TUNICA MEDIA)
ELASTIC AND WHITE FIBROUS TISSUE
VEIN
LINING (TUNICA INTIMA)
OF ENDOTHELIUM
LINING
OUTER COAT
(TUNICA ADVENTITIA)
ARTERY
MUSCLE COAT (TUNICA MEDIA)
ELASTIC AND WHITE FIBROUS TISSUE


ENDOTHELIAL CELLS

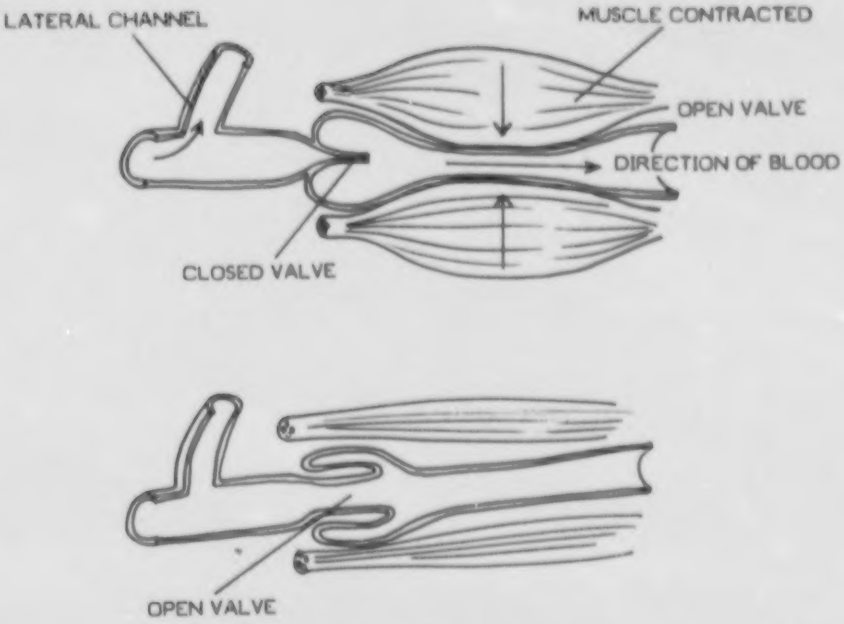

LATERAL CHANNEL
MUSCLE CONTRACTED
OPEN VALVE
DIRECTION OF BLOOD
CLOSED VALVE
OPEN VALVE

Fig. 10. Diagram of valves of a vein

In the **pulmonary** circuit, the pulmonary arteries carry blood containing carbon dioxide from the heart to the lungs. Oxygenated blood from the lungs is returned to the heart by the pulmonary veins. (This is the only instance in the body in which an artery carries deoxygenated blood and a vein carries oxygenated blood.)

Systemic circulation is made up of all other arteries and veins. These vessels carry oxygen and nutrients to all tissues of the body and transport wastes for disposal from all tissues except the lungs.

The Lymph System

The lymph system is a part of the circulatory system in that it aids in returning tissue fluid to the blood vessels. It is made up of the lymphatic capillaries, two large lymph ducts, lymph organs, lymph nodes, and lymph itself.

Every cell of the body must maintain a given fluid volume. There is fluid in each cell (intracellular fluid), and extracellular fluid in blood plasma. The fluid between the cells is called interstitial fluid. Some of this fluid enters the lymph capillaries and is called lymph.

Lymph is the clear, watery fluid found in the lymphatic vessels. It closely resembles plasma, but contains less protein.

The lymph capillaries are a series of collecting vessels that form a network throughout the body. These capillaries carry lymph from the body and drain into the lymphatic veins. Lymphatic veins are similar in structure to blood veins, but they have much thinner walls. The lymphatic veins also have valves to prevent the backflow of fluid. These veins drain into two large ducts, the right lymphatic duct and the thoracic duct. The right lymphatic duct drains lymph from the upper extremities, the right side of the thorax, the right lung and part of the upper area of the liver, and the right side of the head and neck. It delivers the lymph to the right subclavian vein, by which it reenters the circulating blood.

The thoracic duct delivers the lymph from the rest of the body. It connects with and empties into the left subclavian vein. In this way, lymph is returned to the circulatory system to be sent out to the tissues again.

Lymph nodes are small, rounded masses of lymphoid tissue scattered all over the body along the course of lymphatic vessels. They occur in larger numbers in the neck region, the axilla, the inguinal region, in the mesentery of the small intestine and the iliac, lumbar, and thoracic regions. One lymph vessel enters and another leaves each lymph node. Each node contains phagocytes which destroy microorganisms and cellular debris. Also, lymphocytes produced in the lymph nodes enter the lymph as it moves through the lymph nodes and eventually reaches the bloodstream.

The tonsils, thymus, and spleen are made up essentially of lymphatic tissue. These are organs because they are made up of more than one kind of tissue. Each of these produce lymphocytes. The three pairs of **tonsils** in the pharynx help destroy pathogenic microorganisms and protect the entrance of the alimentary and respiratory tracts from bacterial invasion.

The **spleen** is found below the diaphragm behind the stomach. It serves as a blood reservoir and produces some red blood cells. It also destroys worn-out blood cells and produces antibodies.

The **thymus gland** lies behind the sternum. It is larger in children and reaches its maximum size at about puberty. Then it begins to diminish in size, and gradually atrophies in adulthood. The thymus produces lymphocytes and antibodies.

The lymphatic capillaries in the villi of the small intestine are especially modified to collect digested fat, which is then transported by the lymphatic network to the bloodstream. These lymphatic capillaries are called **lacteals**.

The lymph system thus functions as a transport system. It collects and transports lymph (fluid from intercellular spaces) by means of the lymphatic network and returns it to the blood. It also transports digested fats from the villi to the bloodstream. And it protects the body from invading microorganisms.

Disorders and Diseases

Disorders of the blood and cardiovascular system have assumed great importance. Heart disease is currently one of the most common causes of illness and death. The following list and brief descriptions are

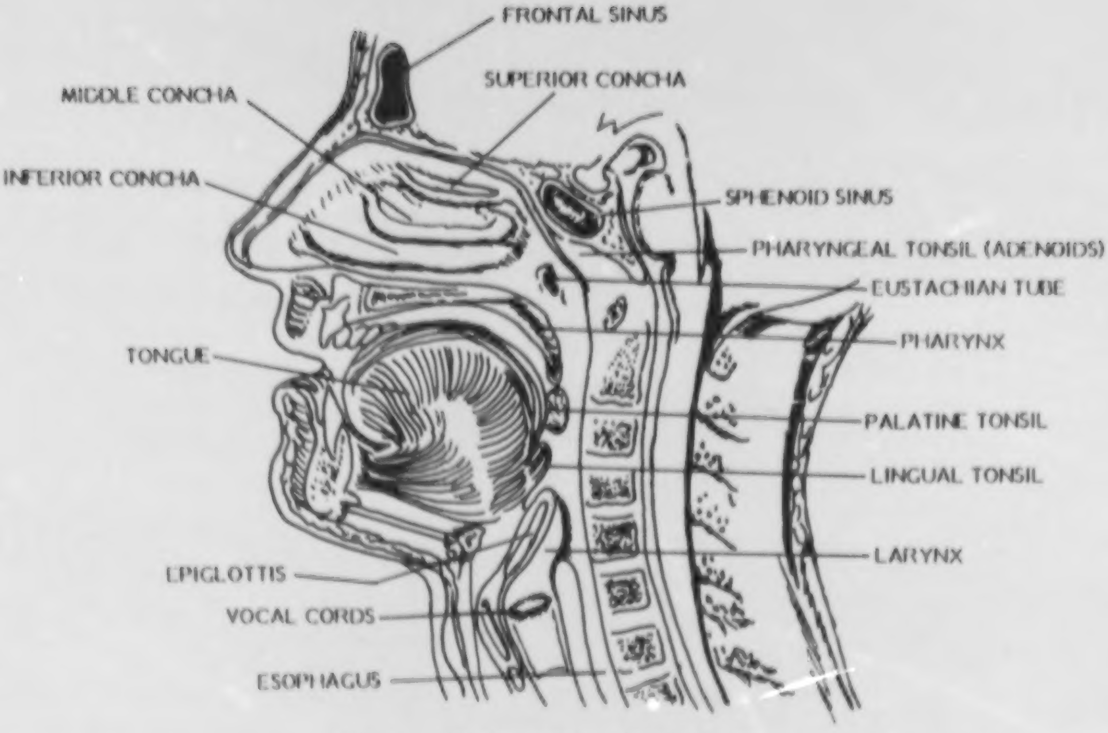

FRONTAL SINUS
MIDDLE CONCHA
SUPERIOR CONCHA
INFERIOR CONCHA
SPHENOID SINUS
PHARYNGEAL TONSIL (ADENOIDS)
EUSTACHIAN TUBE
PHARYNX
TONGUE
PALATINE TONSIL
LINGUAL TONSIL
LARYNX
EPIGLOTTIS
VOCAL CORDS
ESOPHAGUS

Fig. 1. Sagittal section of face and neck

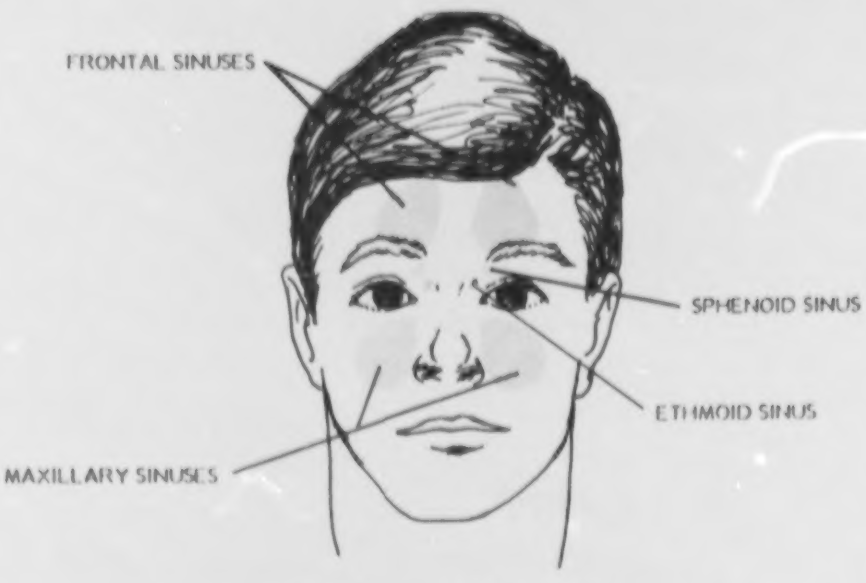

FRONTAL SINUSES
SPHENOID SINUS
ETHMOID SINUS
MAXILLARY SINUSES

Fig. 2. Areas of sinus cavities

6

The Respiratory System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the respiratory system;*
2. *distinguish between breathing (pulmonary ventilation) and external and internal respiration;*
3. *identify the parts of the respiratory system, and give the function of each;*
4. *trace the pathway of inspired and expired air through the respiratory system;*
5. *locate the parts of the respiratory system on a diagram;*
6. *locate and give the functions of the sinuses;*
7. *name the seven openings of the pharynx;*
8. *tell how sound is produced by the vocal cords;*
9. *describe the Heimlich maneuver;*
10. *explain how air is caused to flow in and out of the lungs;*
11. *identify types of breathing;*
12. *explain the movement of gases between alveolar walls and the blood;*
13. *tell how oxygen and carbon dioxide are transported in the blood;*
14. *explain how breathing is controlled by the nervous system and chemical stimulation;*
15. *describe cardiopulmonary resuscitation; and*
16. *identify common diseases of the respiratory system.*

New Terms and Definitions

alveoli—minute, balloonlike sacs in the lung through which oxygen and carbon dioxide are exchanged.

asphyxiation—condition caused by insufficient intake of oxygen; suffocation.

breathing—mechanical process by which atmospheric air is taken into the lungs and waste air is expelled.

ciliated—covered with short, bristlelike hairs.

cyanosis—bluish gray skin color caused by lack of oxygen in the blood.

expiration (exhalation)—to breathe out.

external respiration—the exchange of gases between the lungs and the blood.

inspiration (inhalation)—to breathe in.

intercostal—between the ribs; refers to muscles.

internal respiration—the exchange of gases between the blood and body cells.

medulla—the part of the brain that controls respiration.

olfactory—pertaining to the sense of smell.

pleural—thin tissue covering the lungs and lining the chest cavity. The two pleural surfaces move over each other.

pulmonary—pertaining to the lungs.

meant only to identify some of the most common diseases and disorders.

anemia—deficiency in the number of erythrocytes or reduced hemoglobin. **Sickle-cell anemia** is a hereditary disease due to genetic variation of the hemoglobin molecule, which causes the red blood cells to become sickle-shaped and fragile, with a tendency to rupture.

aneurysm—an abnormal dilatation of blood vessels.

angina pectoris—severe chest pain caused by an insufficient flow of blood to the heart.

arteriosclerosis—thickening, hardening, and loss of elasticity of the arteries.

atherosclerosis—an accumulation of fats and other substances in the arteries.

coronary occlusion—closing off of a coronary artery.

erythroblastosis fetalis—disease of newborns in which red blood cells hemolyze as a result of presence of incompatible Rh antibody in the mother's blood.

hemophilia—sex-linked genetic disorder in which the patient is unable to produce sufficient thromboplastin. The blood does not clot normally, if at all.

hemorrhage—copious bleeding; undue loss of blood.

infectious mononucleosis—acute infectious disease characterized by enlargement and tenderness of lymph nodes, increase in atypical monocytes, fever, sore throat, and general malaise.

ischemia—insufficient blood supply to a given part of the body.

leukemia—disease characterized by uncontrolled production of leukocytes. These abnormal cells crowd out normal white blood cells; also called "cancer of the blood."

murmur—abnormal heart sound.

varicose veins—dilation of veins, usually in the lower extremities.

respiration—the interchange of gases between organisms and the environment; the taking in of oxygen, its use in tissues, and the giving off of carbon dioxide.

sinus—cavity (sinuses in the cranium are called air sinuses).

spirometer—device used to measure the air capacity of the lungs.

surfactant—phospholipid produced by the alveoli that forms a lining that prevents the thin membranes of the alveoli from sticking together.

thoracic—pertaining to the chest region.

Function of the Respiratory System

The respiratory system distributes air from the environment to the lungs and removes carbon dioxide from the lungs. Every cell in the body requires a constant supply of oxygen to carry out its activities. Cells deprived of oxygen die within a few minutes. But most body cells are not close to the organs of respiration, so some means of transport to supply them with oxygen is needed. The capillaries of the circulatory system supply this need. No body cell is more than two cells away from a capillary (except some parts of the eye). Therefore, oxygen from the lungs to the cells and carbon dioxide from the cells to the lungs are transported by means of the blood in the capillaries.

Air is moved into and out of the respiratory system by breathing, or pulmonary ventilation. The intake of air is called **inhalation** or inspiration, and breathing out is **exhalation** or expiration.

Structure of the Respiratory System

Air enters the body through the nose. The external nose, the part with which we are most familiar, is divided into two sections by a wall or septum. The openings to the outside are called nares (nar-eez).

A common nasal problem is nosebleed or epistaxis. Although annoying, it is seldom serious. It is usually the result of injury, local infection, or even drying of the mucous membrane of the nasal passage. Excessive bleeding may require medical treatment.

As the incoming air enters the nose, it must first pass over ciliated mucous membrane. The cilia trap large particles of dust and debris and prevent them from gaining entrance to the nasal passages. The inner wall of each nasal cavity is folded into three ridges or conchae. This increases its surface area (fig. 1). The mucous lining entraps bacteria and particles that evaded the cilia. Also, the air is warmed and moistened as it flows over these folds. Thus, air entering the lungs is warm, moist, and relatively free of bacteria and debris.

The lining of the upper fold of the nasal passage contains olfactory receptors. They are stimulated as air rushes over them, and thus we sense odors.

Even though humans have poorly developed olfactory senses, compared to some animals, we are able to detect hundreds of individual odors and recall them. Our sense of smell is important in identifying factors in the environment and, as we have already noted, in savoring food.

There are four pairs of sinuses that drain into the nasal cavity. These are air-filled cavities in the skull. They are found in the frontal, maxillary, ethmoid, and sphenoid bones (fig. 2). Their functions are to reduce the weight of the skull, to provide mucus for the nasal cavity, and to enhance the resonance of the voice. Sometimes the lining of a sinus cavity swells because of an allergic response, or a bacterial or viral infection. This causes sinusitis.

The **pharynx**, or throat, has been mentioned in discussing the digestive system since food passes through the pharynx to the esophagus. Air from the nasal passages also passes through the pharynx on its way to the larynx. There are actually seven openings into the pharynx; thus, it is truly a terminal. Not only do the two nasal passages, the mouth, the esophagus, and the larynx open into the pharynx, but also the right and left eustachian tubes which extend from the middle ear. Air from the pharynx passes through the eustachian tube to the middle ear and exerts pressure on the tympanic membrane. Air also enters the outer ear and exerts pressure on the tympanic membrane from that side. In this way, air pressure on the tympanic membrane is equalized. Middle ear infections are not infrequent because bacteria from the pharynx may travel by way of the eustachian tube to the middle ear.

1. nose
2. pharynx
3. larynx
4. trachea
5. bronchus
6. bronchioles
7. alveolar duct
8. alveolus

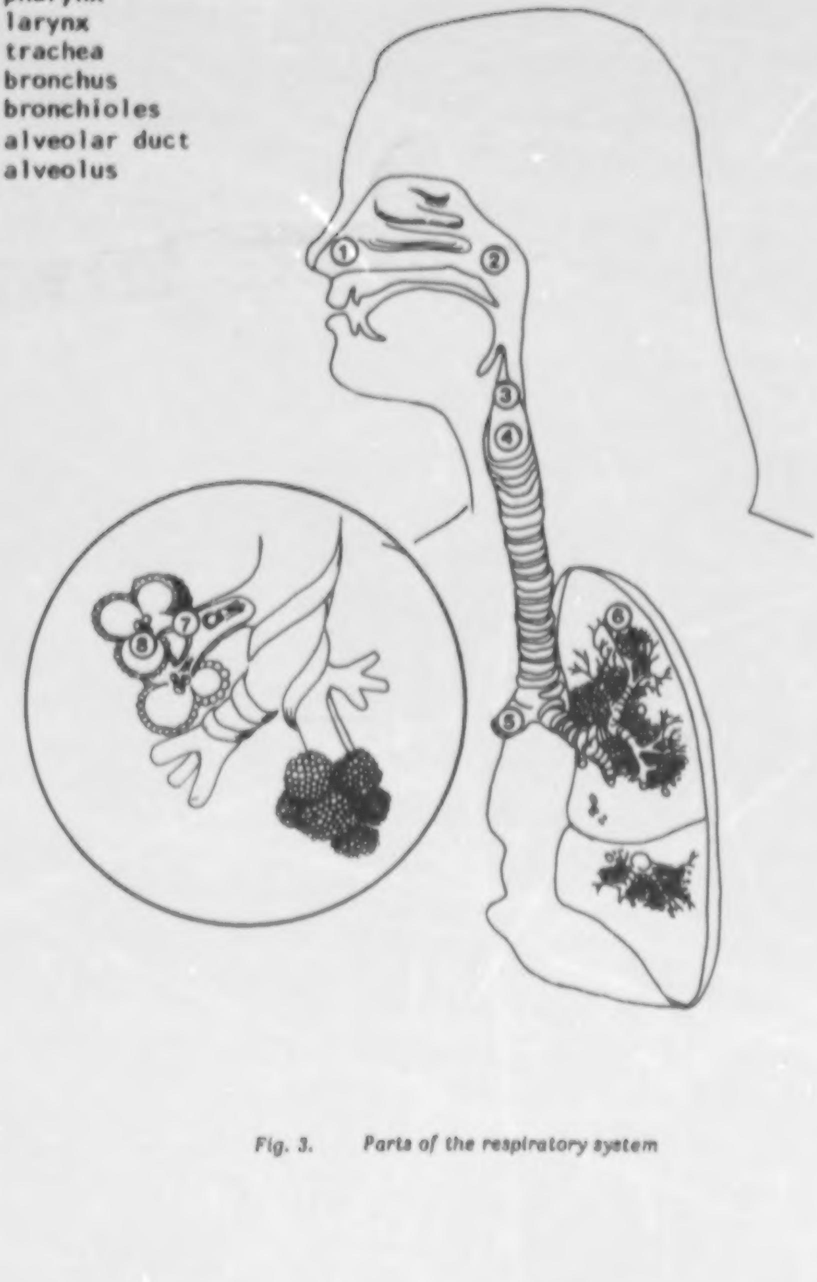


Fig. 3.   Parts of the respiratory system

The pharynx also contains three pairs of tonsils (fig. 1). The pharyngeal tonsils or adenoids are found in the nasopharyngeal region. If these become enlarged, they may fill the space and block the passage of air from the nose to the throat, causing the person to breathe through the mouth. The palatine tonsils are located at the back of the tongue on each side. These are the ones that are most often infected, and the ones most easily seen in throat examinations. The third pair, the lingual tonsils, are at the root of the tongue. Tonsils are primarily lymph tissue. Their function is to destroy pathogenic bacteria entering the pharynx. Sometimes, however, the tonsils themselves become infected, particularly the palatine tonsils.

The pharynx is not only a passageway for food and air. Some vowel sounds are formed by the relaxing and constricting of muscles in the pharyngeal walls.

The **larynx** is just below the pharynx at the upper end of the trachea. The opening into the larynx from the pharynx is called the glottis. The epiglottis, already mentioned, is the structure that covers the glottis during swallowing and prevents food or liquid from entering the larynx (see fig. 3). The larynx contains the vocal cords which make possible most voice sounds; thus, it is commonly called the "voicebox." The vocal cords are actually a pair of folds in the mucous lining of the larynx. Under these folds are elastic ligaments held rigidly in place by their attachment to cartilage. As air passes through the larynx, the glottis is narrowed, and the vocal folds (or vocal cords) vibrate, producing the voice. Many structures such as the nose, sinuses, and the mouth are also involved in the tone and quality of the voice. The vocal cords in males are usually longer and thicker. Men usually have a lower voice range than women because their vocal cords vibrate more slowly. The thinner, shorter vocal cords of females vibrate more rapidly, producing a higher range of sound.

Laryngitis is an inflammation of the larynx, often including inflammation of the vocal cords. If the vocal cords swell so that they cannot vibrate normally, hoarseness or even total loss of voice may occur.

The **trachea** extends from the larynx down to the bronchi. It is a tubelike structure about 4 1/2 inches (11 cm) long and 1 inch (2.5 cm) in diameter. It is in front of the esophagus. The tracheal walls are protected by "C"-shaped cartilage rings. These provide support and prevent collapse and obstruction of the airway. The open parts of the cartilage rings face the esophagus, making it possible for the esophagus to expand during swallowing.

The function of the trachea is to provide a passageway for inhaled and exhaled air. If the trachea is obstructed for even a short time, death will result from asphyxiation. In fact, one of the most frequent causes of accidental death is choking on food. It can easily be distinguished from heart attack, because the patient cannot speak or breathe, usually panics, and—if not rescued—becomes pale, then cyanotic, and ultimately loses consciousness. The offending particle (food or foreign object) is usually lodged in the pharynx, the opening of the larynx, or even the trachea.

Food choking usually occurs during inspiration, when the lungs are expanded. Pressure on the diaphragm increases pressure on the air in the lungs and forces air against the lodged particle. The first aid procedure is to remove the object from the airway. Back blows are given first, following this procedure:

1. Place yourself at the side or slightly behind the victim, who may be standing or sitting.
2. Place one hand on the victim's chest for support, and position the head at chest level or below.
3. Strike the victim with the heel of the hand over the spinal column between the shoulder blades.
4. Give four or five quick blows. If this does not dislodge the particle, the Heimlich maneuver should be started at once (see fig. 4).

Heimlich Maneuver

1. Place yourself behind the victim.
2. Wrap your arms around the victim's waist, making a fist with one hand.
3. Place the thumb side of your fist against the victim's abdomen just above the navel and below the rib cage (about 4 to 6 inches below the "V" formed by the sternum).

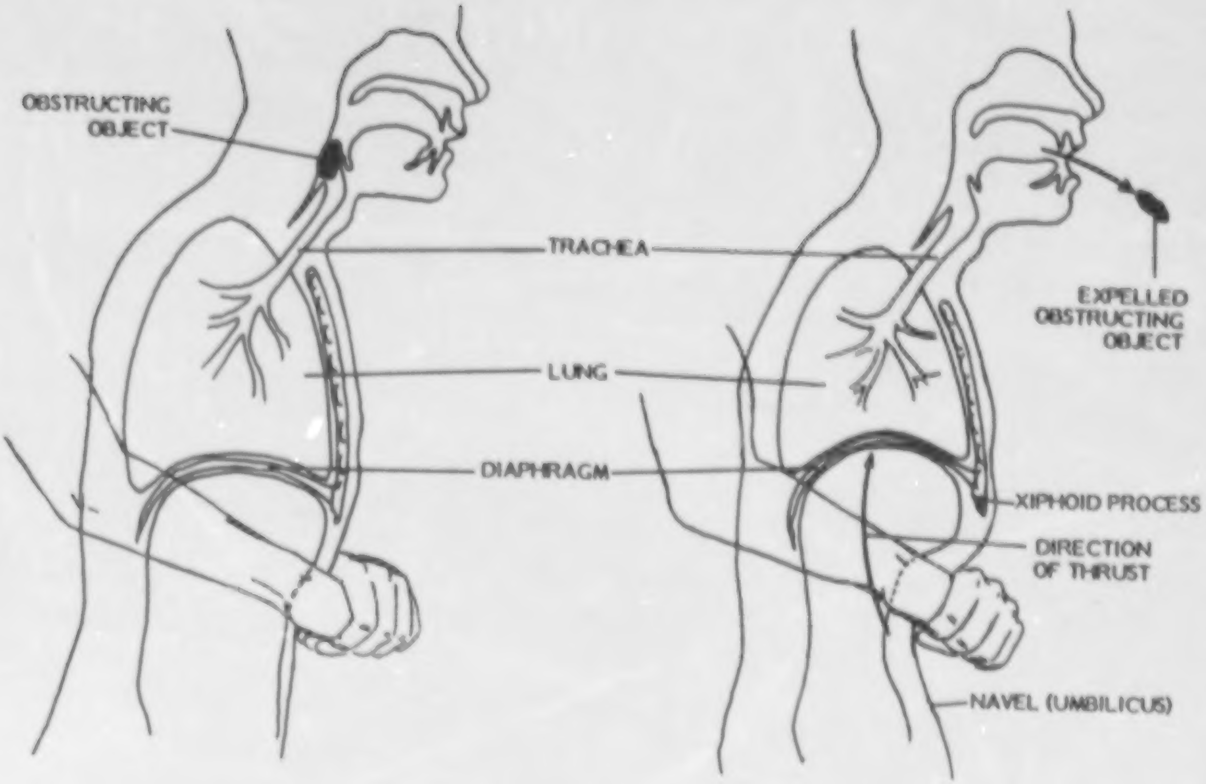

OBSTRUCTING OBJECT
TRACHEA
EXPELLED OBSTRUCTING OBJECT
LUNG
DIAPHRAGM
XIPHOID PROCESS
DIRECTION OF THRUST
NAVEL (UMBILICUS)

Fig. 4. Heimlich maneuver

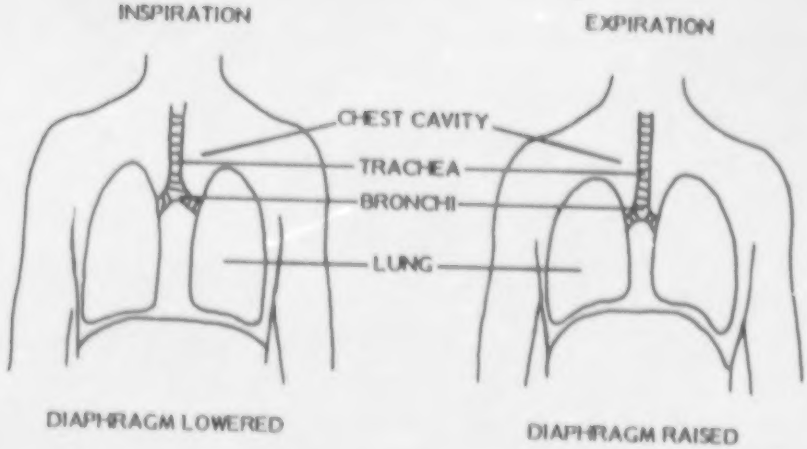

INSPIRATION
EXPIRATION
CHEST CAVITY
TRACHEA
BRONCHI
LUNG
DIAPHRAGM LOWERED
DIAPHRAGM RAISED

Fig. 5. Action of diaphragm in breathing

4. Grasp the fist with the other hand, and press it into the victim's abdomen with a quick upward thrust.
5. Repeat several times if necessary to dislodge the obstruction.

The trachea divides at the lower end to form the left and right bronchi. The **bronchi** lead from the trachea to each lung. The bronchi, like the trachea, are protected by "C"-shaped cartilage rings. As the bronchi actually enter the lungs, they branch to form smaller divisions, the secondary bronchi. These continue to branch, forming bronchioles. Such a pattern is reminiscent of the branching of trees, so this whole assembly is often spoken of as the bronchial tree.

The **bronchioles** divide into smaller and smaller structures until they become microscopic branches which further divide to form alveolar ducts. These ducts terminate into alveolar sacs, the walls of which are made up of alveoli.

The **lungs** are a pair of lobed organs found in the chest cavity. They extend from the diaphragm to the clavicle. The left lung is divided into two segments or lobes, and the right into three lobes. The lungs "fit" around the heart. The lungs are covered with a thin tissue, the pleura. The inner surface of the chest cavity which houses the lungs is also lined with pleural tissue. As the chest moves during inspiration and expiration, the two pleural surfaces move smoothly one against the other.

The lungs have a spongelike consistency because they are actually made up of the bronchioles, the alveolar ducts, and the alveoli. The alveoli are tiny, balloonlike structures, the walls of which are only one cell thick. This makes possible the transport of gases through the alveolar walls. In this way, oxygen from inhaled air enters the lung tissue, and carbon dioxide from body cells is exhaled from the lungs.

Because the alveolar walls are so delicate, you might expect that they would stick together like a deflated balloon on expiration, thus keeping them from retaining air. This does not happen because a phospholipid called **surfactant** is produced by alveolar cells. Surfactant coats the cells and prevents sticking. In some diseases, the patient has an inadequate supply of surfactant, and the patient's oxygen supply is curtailed.

The **diaphragm** is a thin sheet of muscle that separates the chest and abdominal cavities. The chest cavity contains the esophagus, trachea, bronchi, lungs, and heart. The abdominal cavity contains the organs of digestion. The esophagus penetrates the diaphragm to enter the stomach.

Respiration is the interchange of gases between organisms and the environment—that is, the taking in of oxygen, its use in tissues, and the giving off of carbon dioxide. The exchange of gases in the lungs (external respiration) and the exchange of gases in cells (internal respiration) are phases of respiration.

Air and Gas Movement

The movement of air into and out of the lungs is governed by the same physical laws as the movement of any other gas. Gas molecules move from one area to another because of differences in pressure. The flow is always to the area of lower pressure. Atmospheric pressure at sea level is 760 mm Hg at 0°C. If the pressure within the lung is less than 760 mm Hg, air flows into the lung (inspiration occurs). As the pressure in the lung increases, as a result of inspiration, to more than 760 mm Hg, air flows out of the lung (expiration occurs).

So, in order for inspiration and expiration to occur, a difference in pressure between the lungs and the atmosphere must take place. This is accomplished by the diaphragm and chest muscles. The diaphragm contracts, moves downward, and increases the volume of the chest cavity vertically, and the chest muscles contract and cause the chest cavity to increase transversely. This decreases intrathoracic pressure, and air rushes in. When the diaphragm and chest muscles relax, the chest cavity decreases in size, intrathoracic pressure increases, and air rushes out (fig. 5).

The volume of air exchanged in breathing can be measured with a device called a spirometer. This information is valuable in the diagnosis and treatment of disease.

There are specific terms used to describe **types of breathing**. Recognition of the various types is important clinically. The suffix "pnea" comes from "pnein," which means to breathe.

1. **eupnea**—normal, quiet breathing.
2. **apnea**—cessation of breathing.
3. **hyperpnea**—abnormally increased breathing.
4. **Cheyne-Stokes breathing**—respirations gradually increase in rapidity and volume until they reach a climax, then gradually subside, cease entirely for a few seconds, then begin the cycle again.

Now we must discuss **external respiration**, or the exchange of the gases oxygen and carbon dioxide between the alveoli of the lungs and the blood in the capillaries. You will recall that air enters and leaves the lungs because of differences in air pressure and the pressure in the chest cavity. In external respiration, the transfer of gases is again the result of differences in pressure. The following terms are used in discussing gas exchange:

P = partial pressure (it precedes the chemical symbol for a gas)
PO_2 = partial pressure of oxygen
PCO_2 = partial pressure of carbon dioxide

Air rich in oxygen is taken into the alveoli of the lungs. The PO_2 of alveolar air is greater than the PO_2 of the blood in the capillaries surrounding the alveoli. Thus, oxygen will leave the alveoli and enter the capillaries because it will move down its pressure gradient. (Gases may easily pass through capillary walls and alveolar walls.)

In internal respiration, gases are exchanged between the blood and body cells. When the oxygen-rich blood reaches the cells, the PO_2 of the capillary blood is greater than the PO_2 of the cells. Therefore, oxygen will leave the blood and enter the cells. There it combines with glucose in the cells to release energy. Carbon dioxide is given off in this process. The PCO_2 of the cell is greater than the PCO_2 of the capillary blood, and carbon dioxide moves from the cells to the blood. Again, the movement is governed by the pressure differential between the cell and the capillary. The PCO_2 of the capillary blood is greater than the PCO_2 of the alveoli. Therefore, carbon dioxide moves into the alveoli and is ultimately expired. It is the pressure differential that makes possible the flow of gases in each direction. For example, if the PO_2 in the capillaries is 40 mm of Hg, and the PO_2 in the alveoli is 100 mm of Hg, oxygen would flow into the capillaries from the alveoli. Conversely, if the PCO_2 in the capillaries is 46 mm of Hg, and the PCO_2 in the alveoli is 40 mm of Hg, the carbon dioxide would flow from the capillaries into the alveoli (fig. 6).

Some oxygen is carried in the blood plasma, but most oxygen combines chemically with the hemoglobin of the red blood cells to form the compound oxyhemoglobin. Almost all carbon dioxide is carried in the blood dissolved in the plasma, but some is also transported by the red blood cells.

Control of Breathing

The control of breathing is a complex mechanism that involves both the nervous system and chemical stimulation. The center for nerve control is found in the medulla of the brain. One main nerve pathway is the vagus nerve which goes to the lungs. It also branches to other body parts, such as the skin, nose, larynx, and abdominal organs. The phrenic nerve goes from the medulla to the diaphragm. Thus, messages from the medulla stimulate the organs of breathing, and stimuli from other areas can be received by the medulla and affect breathing.

The chemical factor that controls breathing refers to the carbon dioxide level in the blood. A slight increase stimulates the medulla. This stimulation causes the medulla in turn to send a message to the lungs and diaphragm to increase the rate of respiration. With this increased rate, carbon dioxide is rapidly eliminated and air rich in oxygen is taken in. The carbon dioxide level drops, and the rate of breathing decreases. This cycle continues constantly with no need for conscious control.

It is possible for an individual to voluntarily alter a breathing pattern, but it is impossible to stop breathing for very long. After only a few moments, the buildup of carbon dioxide will stimulate the breathing center of the brain and breathing will automatically resume. Sometimes a person may hold their breath until they lose consciousness, but then the breathing center will cause breathing to begin again and the person will regain consciousness.

Cardiopulmonary Resuscitation

Any study of the respiratory system should include cardiopulmonary resuscitation (CPR). This first aid measure is indicated when patients have apparently stopped breathing and/or the heart has stopped beating.

If you encounter a person who is cyanotic, has stopped breathing, and is unconscious, CPR should be begun at once. Before you begin, check the ABCs of CPR. "A" is to establish an open airway, "B" is to determine if the person is breathing, and "C" is to establish circulation. The procedure for CPR is as follows:

1. Shake the victim and shout, "Are you okay?" Call for help.
2. Tilt the head back to open the airway. Check for obstructions in the mouth and throat.
3. Check to see if the victim is breathing. Look, listen, and feel for 5 to 10 seconds. Put your ear over the victim's mouth, and observe the chest to see if the victim is breathing.
4. If there is no evidence of breathing, keep the head tilted back, pinch the nose, and place your mouth over the victim's mouth to form a seal.
5. Give four quick, full breaths, and observe the person's chest rise with each breath.
6. Check for a carotid pulse and breathing.
7. If the victim is still not breathing, and there is no pulse, begin compressions.
8. To compress the chest, kneel at the victim's side near the chest.
9. Place the heel of one hand just above the lowest part of the sternum.
10. Place the other hand on top of the positioned hand.
11. Bring your shoulder up and directly over the victim's sternum, keep your arms straight, and compress downward. Keep your hands positioned so only the heel of the hand is on the sternum.
12. Do not remove your hands from the victim's chest, but relax after each compression using a rhythm. Allow time for the chest to return to normal after each compression.
13. If you are working alone, give 15 compressions to every two breaths to the victim. If it is a two-person rescue, give five compressions to one breath to the victim.
14. Continue until help arrives and you are relieved by someone trained to do CPR. Check at intervals for return pulse and spontaneous breathing.

More complete information on both the Heimlich maneuver and CPR is available from local agencies such as the American Red Cross or the American Heart Association. The information provided here is intended to be only introductory.

Diseases and Disorders

The various parts of the respiratory system are subject to diseases and disorders. Some of the most common are listed here.

asthma—shortness of breath with wheezing caused by obstruction of the flow of air in small bronchi or bronchioles due to swelling or spasm of the bronchial tubes or their mucous membranes. Since the walls of the bronchioles contain no cartilage, muscle spasms can close the airways.

atelectasis—collapse of part or all of a lung with incomplete expansion of the alveoli.

bronchiectasis—dilation of bronchi or bronchioles.

common cold—most widespread of all communicable diseases; characterized by swollen and inflamed mucous membrane of the nose and throat.

cough—mechanism for clearing obstruction from the airway.

emphysema—swelling or distention of air passages and alveoli. The alveoli remain filled with air during expiration.

hyaline membrane disease—respiratory disease of the newborn. The infant lacks surfactant, and thus the alveoli tend to collapse.

influenza—acute, contagious, viral respiratory infection characterized by inflammation of the upper respiratory tract, generalized aches, and fever.

laryngitis—inflammation of the larynx; may result in hoarseness or loss of voice if vocal cords are inflamed and swollen.

nosebleed (epistaxis)—nosebleed may result from injury, local infections, or drying of the mucous membrane.

pharyngitis—inflammation of the pharynx; sore throat.

pleurisy—inflammation of the pleura or lining of the lungs and chest cavity. The resulting swelling causes the linings to rub, causing friction and pain.

pneumonia—infection and inflammation of the alveoli; may be caused by viruses, bacteria, or chemical irritants.

sinusitis—inflammation of a sinus.

tuberculosis—inflammation of the lungs and pleurae caused by the bacterium **Mycobacterium tuberculosis.** It occasionally occurs in other parts of the body.

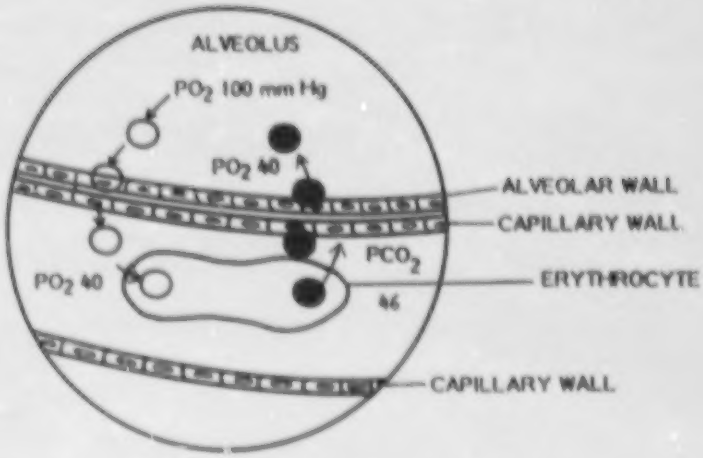

ALVEOLUS
PO2 100 mm Hg
PO2 40
ALVEOLAR WALL
CAPILLARY WALL
PCO2 46
PO2 40
ERYTHROCYTE
CAPILLARY WALL

Fig. 6. Exchange of gases

7

The Nervous System and Special Senses

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the nervous system and special senses;*
2. *identify the main parts of the nervous system;*
3. *locate and give the functions of the parts of the brain;*
4. *explain the importance of a constant oxygen supply to the brain;*
5. *tell how the meninges and cerebrospinal fluid protect the brain;*
6. *locate the spinal cord;*
7. *give the function of cranial and spinal nerves;*
8. *describe the autonomic nervous system;*
9. *tell the function of each part of a neuron, and of three types of neurons;*
10. *list types of neuroglia;*
11. *describe the pathway of stimulus to response;*
12. *describe a reflex arc;*
13. *name and locate the major parts of the ear;*
14. *list the parts of the ear concerned with balance and equilibrium;*
15. *trace the pathway of auditory stimulation to the brain;*
16. *name and locate the major parts of the eye;*
17. *list accessory parts of the eye;*
18. *identify common errors in vision;*
19. *discuss the perception of odors;*
20. *tell why pain is a protective sense; and*
21. *identify common diseases and disorders of the nervous system and special senses.*

New Terms and Definitions

effectors—muscles or glands that respond to stimulation in a reflex arc.

extrinsic—coming from without.

fissure—a groove, cleft, or slit.

foramen—an opening; a hole in a bone for the passage of nerves or blood vessels.

ganglion (pl. ganglia)—mass of nerve tissue outside the spinal cord or brain.

intrinsic—coming from within.

lacrimal—pertaining to tears.

meatus—passage or opening.

melanin—dark pigment which gives color to hair, skin, and eyes.

motor neurons—neurons that transmit impulses away from the brain and spinal cord.

neuroglia—nerve cells found in the brain that have supporting or repair functions.

neuron—nerve cell body and its extensions.

ossicle—small bone.

peripheral—away from the center; toward the outside of the body.

pneumotaxic—the area of the pons that is part of the respiratory center.

receptor—end of a dendrite of a sensory neuron.

referred pain—pain that the body interprets as coming from one part of the body

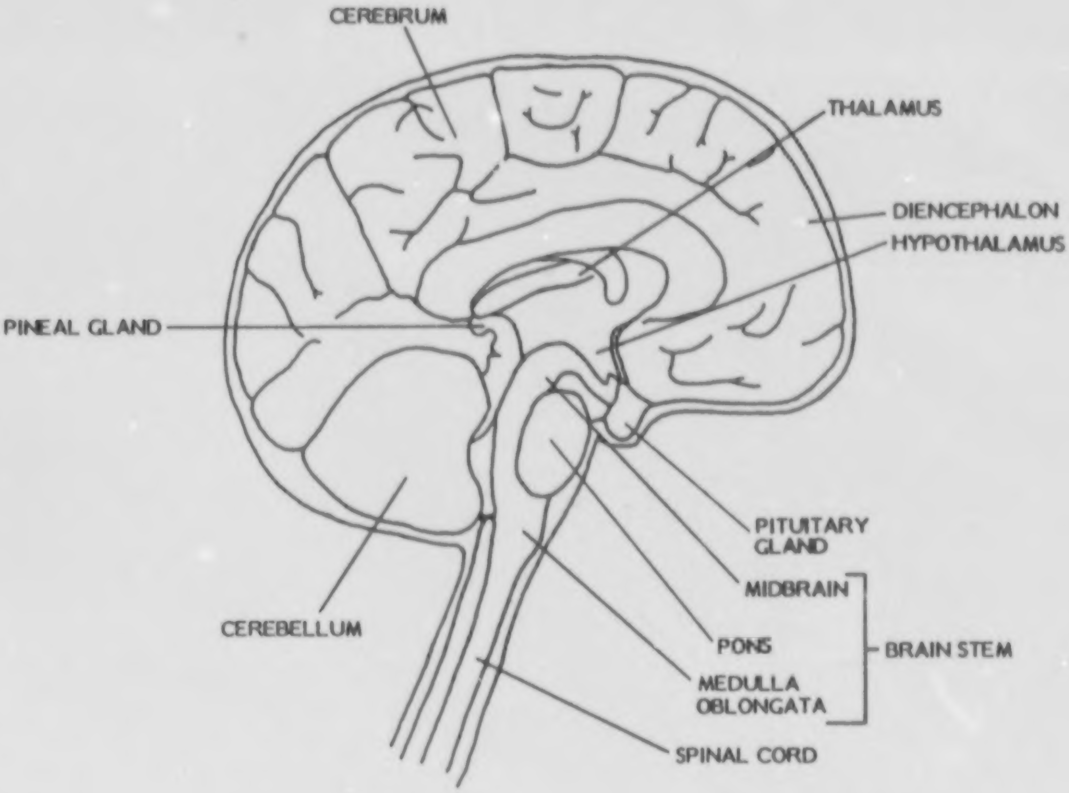

CEREBRUM
THALAMUS
DIENCEPHALON
HYPOTHALAMUS
PINEAL GLAND
PITUITARY GLAND
MIDBRAIN
CEREBELLUM
PONS
BRAIN STEM
MEDULLA OBLONGATA
SPINAL CORD

Fig. 1. Sagittal section of brain

when the pain originates in another area instead.

reflex—an involuntary response to a stimulus.

refract—to bend; to deflect.

sensory neurons—neurons that transmit impulses to the spinal cord.

socket—a hollow in a part for another organ.

sulci—shallow grooves in the surface of the brain.

synapse—minute space between the dendrite of one neuron and the axon of another.

The Nervous System

The nervous system is the communication and control system for the entire body. It is by means of the nervous system that messages from every body part are received, and by which appropriate responses are made. It makes it possible to survive in a constantly changing environment.

The nervous system is made up of two main parts—the central and peripheral nervous systems. The **central nervous system** consists of the brain and spinal cord. The **peripheral nervous system** is made up of nerves that extend to outlying parts of the body. It includes cranial nerves, spinal nerves, autonomic nerves, and ganglia.

The brain is the control center of the entire body. It is a large organ weighing about 3 pounds. It fills the cranial cavity and is well protected by the bones of the cranium. The cerebrum, cerebellum, and diencephalon are larger expanded parts of the brain that sit atop the brain stem. Within normal limits there is no correlation between brain size and intelligence.

The brain is made up of various parts or divisions: the cerebrum; the diencephalon, which includes the thalamus and hypothalamus; the cerebellum; and the brain stem, made up of the medulla oblongata, the pons, and the midbrain (fig. 1).

The largest part of the brain is the **cerebrum**. It makes up about two-thirds of the volume of the brain. It is divided lengthwise into two main parts, or hemispheres, by a deep groove. Each hemisphere is divided again by fissures to form four lobes (fig. 2). The lobes are named for the areas of the skull that protect them. Thus, they are the temporal, frontal, parietal, and occipital. Not only is the cerebrum divided by fissures, but each lobe has many shallow grooves called sulci, with accompanying ridges. The overall external appearance of the brain is wrinkled.

The functions of the cerebrum are divided broadly into sensory, motor, and association (or integrative) areas. Examples of **sensory functions** are visual, auditory, olfactory, taste, pain, temperature, touch, pressure, evaluation, comparison, and discrimination. **Motor functions** include (1) the control of individual muscles or groups of muscles; (2) learned motor activities or skilled movements, such as typing, writing, or adjusting a microscope; and (3) the ability to read or to speak.

The **association** areas are concerned with the association of motor and sensory areas. It is in these areas of the cerebrum that emotions, judgment, intelligence, reason, or, in general, "mental" activities take place. It is the activity of the cerebrum that makes humans intellectually superior to all other creatures.

The **cerebellum** is composed of two lateral hemispheres. It lies dorsal to the pons and medulla oblongata and just below the posterior portion of the cerebrum. It controls the movement of skeletal muscles at the subconscious level and regulates their movement so that it is smooth and coordinated. Messages from the inner ear that make possible the control of equilibrium and posture are also received in the cerebellum.

The **pons** is a rounded projection on the ventral surface of the brain. It appears as a broad band of transverse fibers. It is above the medulla and anterior to the cerebellum. Pons means "bridge," and is an apt name because the pons literally serves as a bridge to transmit impulses from one brain part to another. It sends messages from one side of the cerebellum to the other, from the cerebellum to the cerebrum and midbrain, and between the medulla oblongata and spinal cord. It contains the pneumotaxic center which controls respiration. The nuclei of cranial nerves V, VI, VII, and VIII are also located in the pons.

Other areas of the brain are the **midbrain,** which lies just above the pons; the **thalamus,** just above the midbrain; and the **hypothalamus,** below the thalamus.

The pituitary gland, one of the endocrine glands, is below the hypothalamus and

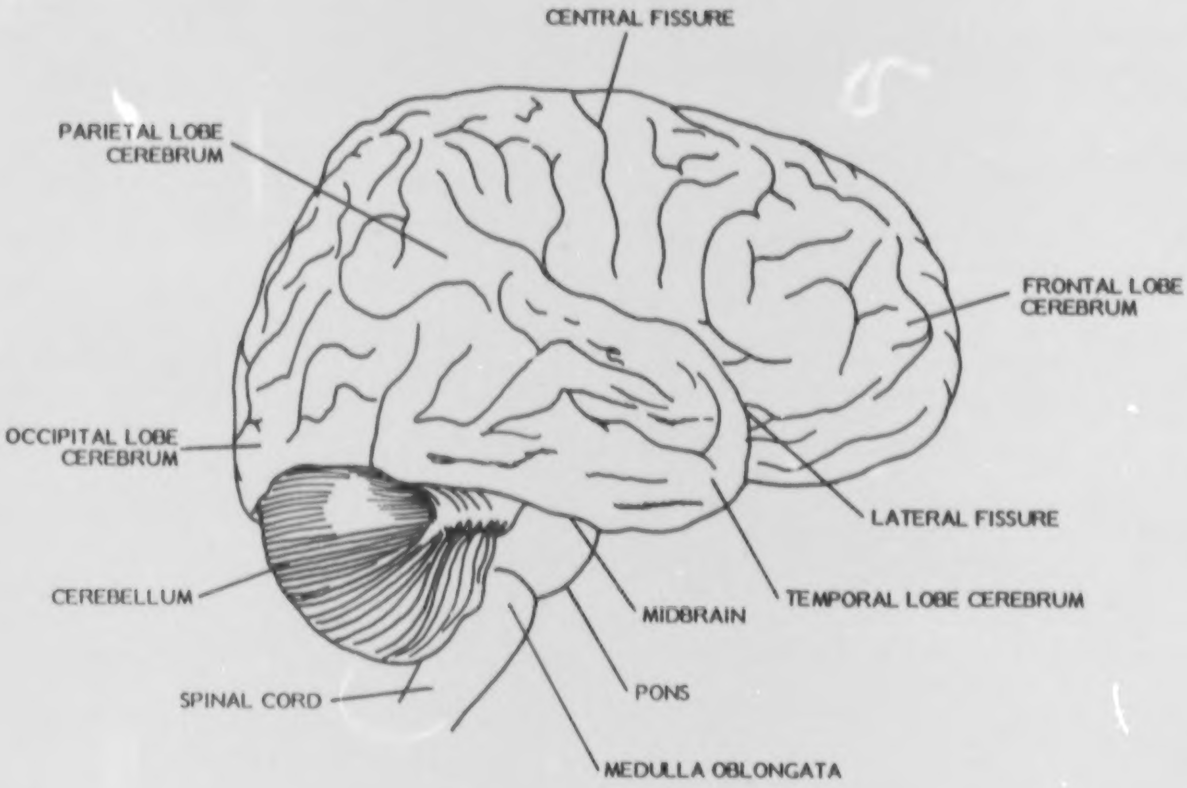

CENTRAL FISSURE
PARIETAL LOBE CEREBRUM
FRONTAL LOBE CEREBRUM
OCCIPITAL LOBE CEREBRUM
LATERAL FISSURE
CEREBELLUM
TEMPORAL LOBE CEREBRUM
MIDBRAIN
SPINAL CORD
PONS
MEDULLA OBLONGATA

Fig. 2. Parts of brain

attached by a stalk. It is well protected by the sphenoid bone of the cranium. A second endocrine gland, the pineal body, lies dorsal to the thalamus.

The **medulla oblongata**, usually called just the medulla, is continuous with the spinal cord posteriorly and with the pons anteriorly. It serves as a pathway for impulses between the spinal cord and the pons. It also contains the control centers for vital body functions such as heartbeat, respiration, and blood pressure. The nuclei of origin for cranial nerves VIII* and IX are also found in the medulla (fig. 3). A "rabbit punch," or short, chopping blow to the back of the head, may damage the medulla with serious consequences. Injury to the control centers for respiration or heartbeat may indeed result in death.

The brain is well supplied with blood vessels. This is essential because the nerve cells of the brain require a constant supply of oxygen and nutrients. Brain cells deprived of oxygen for even 1 or 2 minutes will be weakened as a result of oxygen starvation, and unconsciousness may occur. Four minutes of oxygen deprivation may cause permanent injury, brain damage, or even death. If the brain is deprived of glucose (below 40 gm/100 ml blood), dizziness, confusion, convulsions, and loss of consciousness may ensue.

The brain and spinal cord are protected not only by the bones of the cranium and vertebrae, but also by a fluid, cerebrospinal fluid, which cushions them from blows or shock. The fluid is also found within the canal or the spinal cord and in spaces called ventricles found beneath and inside the brain. The fluid is formed continuously from the blood, circulates around the brain and spinal cord, and returns to the blood. Cerebrospinal fluid is crystal clear. It contains a few leukocytes, chemicals such as glucose, and protein. It is sometimes used as a diagnostic tool. In such instances, a "spinal tap" is done. That is, a needle is inserted between lumbar vertebrae, usually the third and fourth. (The spinal cord only extends as far as the first or second vertebrae and thus is not injured.) A small amount of cerebrospinal fluid is drawn for testing. At the same time, spinal fluid pressure is determined. Increased pressure indicates an obstruction in the flow of the cerebrospinal fluid and may indicate a tumor or blood clot.

The spinal cord lies within the spinal canal encased in the vertebrae and extends from the medulla to the first or second lumbar vertebrae. It is made of nerve tissue. It contains centers for reflex action and also serves as a two-way conduction pathway between the brain and nerves to the trunk and limbs.

The brain and spinal cord are surrounded, enclosed, and protected by the meninges. The **meninges** consist of three layers of connective tissue. The outside layer is called the dura mater. It is a strong, white fibrous cover. It serves as the outer layer of the meninges and as the inner periosteum of cranial bones. The middle meningeal layer is called the arachnoid membrane. It is a delicate, cobweb-like tissue that allows space for fluids. The inner layer, called the pia mater, attaches to the nerve tissue of the brain and spinal cord. The pia mater contains blood vessels and dips into all the depressions of the brain. The meninges of the spinal cord extend inside the spinal cavity below the end of the spinal cord.

The **peripheral nervous system** is made up of nerves that extend to the outlying parts of the body. It includes cranial nerves and spinal nerves. The **cranial nerves** are twelve pairs of symmetrically arranged nerves that attach to the undersurface of the brain. They leave the cranial cavity by means of the foramen of the skull. They conduct impulses between the brain and various structures of the head, neck, and thoracic and abdominal cavities. Cranial nerves are indicated by Roman numerals. Figure 3 summarizes the names, number, origin, distribution, and function of the twelve cranial nerves.

There are thirty-one pairs of symmetrically arranged **spinal nerves** attached to the spinal cord. They conduct impulses between the spinal cord and parts of the body that are not supplied by cranial nerves. They are named for the region of the spinal cord from which they originate, and numbered using Roman numerals.

The **autonomic nervous system** controls the involuntary or automatic functions of

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* Nerve VIII has nuclei of origin in both the medula and the pons.

No.	Name	Origin	Distribution	Function
I	Olfactory	olfactory lobe	nasal mucous membrane	sensory—smell
II	Optic	retina	retina	sensory—vision
III	Oculomotor	midbrain	ocular muscles except lateral rectus and superior oblique	motor
IV	Trochlear	roof of midbrain	superior oblique muscle	motor
V	Trigeminal	midbrain and pons		
	ophthalmic		cornea, nasal mucous membrane, skin of face	sensory
	maxillary		skin of face, oral cavity, tongue, teeth	sensory
	mandibular		muscles of mastication	motor
VI	Abducens	pons	lateral rectus muscle of eye	motor
VII	Facial	pons	muscles of facial expression	motor sensory taste (anterior 2/3 of tongue)
VIII	Vestibulo-cochlear (auditory)	pons medulla		
	vestibular		internal auditory meatus	sensory—equilibrium
	cochlear		internal auditory meatus	sensory—hearing
IX	Glossopharyngeal	medulla	sensation of pharynx; posterior 1/3 of tongue parotid gland	sensory—pharynx, tongue, taste motor—pharyngeal muscle
X	Vagus	medulla	pharynx, larynx, heart, lungs, esophagus, stomach, abdominal viscera	sensory motor
XI	Accessory	medulla	muscles of shoulder	motor
XII	Hypoglossal	medulla	muscles of tongue	motor

Fig. 3. Cranial nerves

the body. These activities include the action of glands, the activity of the smooth muscles, of hollow organs, and the heart. The autonomic nervous system is divided into the sympathetic and parasympathetic systems. The sympathetic prepares the body for stressful situations such as fear, anger, or pain. The parasympathetic acts as a balance for the sympathetic and brings about a return to normal activity of the autonomic nervous system. Chemicals to bring about these changes are released as needed.

As any other tissue, nerve tissue is made of cells, called neurons and neuroglia. **Neurons** are specialized to transmit impulses and are adapted for this purpose (fig. 4). They are made up of the same parts found in any typical cell, such as cytoplasm, nucleus, and organelles. They also contain structures found only in nerve cells—Nissl bodies, neurofibrils, cytoplasmic extensions which conduct impulses, a myelin sheath, and the neurilemma.

Nissl bodies are found in the main body of the cell and synthesize protein. **Neurofibrils** seem to provide support.

The **extensions** are called dendrites and axons. The multiple dendrites are short and have tiny branches at the ends, which are receptors. These receive stimuli that are conducted through the dendrite to the nerve cell body. Each neuron has a single axon. Axons vary in length from a few millimeters to 3 feet. They conduct impulses away from the nerve cell body. Axons are also called nerve fibers.

The **myelin sheath** covers the nerve fibers. It has a high fat content and thus appears white. Myelinated fibers make up the white matter of the brain and spinal cord. Nerves outside the brain and spinal cord are cordlike structures composed of bundles of nerve fibers and are also white in appearance.

The **neurilemma** is a sheath that covers the myelin in peripheral nerves. Nerve cells of the brain and spinal cord lack the neurilemma. The neurilemma is essential in the regeneration of damaged or cut peripheral nerve fibers. Since nerve cells of the brain and spinal cord lack the neurilemma, they are unable to regenerate.

The neurons of the brain are formed by mitotic cell division during prenatal development and for a few months after birth. Then the mitotic apparatus is lost and no further neurons are produced. Existing neurons grow rapidly in size during early childhood, but are unable to reproduce. Thus, neurons of the central nervous system lost in injury or disease are not replaced.

There are three types of neurons. Sensory (afferent) neurons transmit impulses to the spinal cord. Motor (efferent) neurons transmit impulses away from the brain or spinal cord to muscles or glands. Connecting (interneuron) neurons conduct impulses from sensory neurons to motor neurons.

About half of the nerve cells of the brain are **neuroglia** (fig. 5). The neuroglial cells make up a fine web of tissue, which acts as the connecting or supporting tissue in the brain. Some of them play an important role in the reparation of damaged nerve tissue in peripheral nerves. The three types of neuroglial cells are astrocytes, oligodendrocytes, and microglia.

Astrocytes (star-shaped cells) have several threadlike branches which attach themselves to other nerve cells in the brain and spinal cord and to tiny blood vessels. In this way they support these structures and bind them together.

Oligodendrocytes have fewer and shorter processes than astrocytes. They form rows of connective tissue between neurons of the brain and spinal cord and thus provide support. Astrocytes and oligodendrocytes play a role in myelin formation, in the transport of material to neurons, and in helping to maintain the acid-base balance of the environment of the neurons.

Microglia are the smallest of the neuroglial cells. They have few processes and can move about to areas of inflamed or damaged nerve tissue where they phagocytize microbes and destroy cellular debris.

The function of the neurons of the nervous system is to respond to stimulation. There are several steps between stimulus and response. An oversimplified example could be the response to the ringing of an alarm clock.

Neurons respond to environmental change—the shrill sound of an alarm clock. Auditory receptors (sensory) in the ear are stimulated by the sound of the alarm. This stimulation causes the (sensory) neurons of the ear to send an impulse to the brain. Neurons in the brain interpret these impulses as sound, and identify the specific

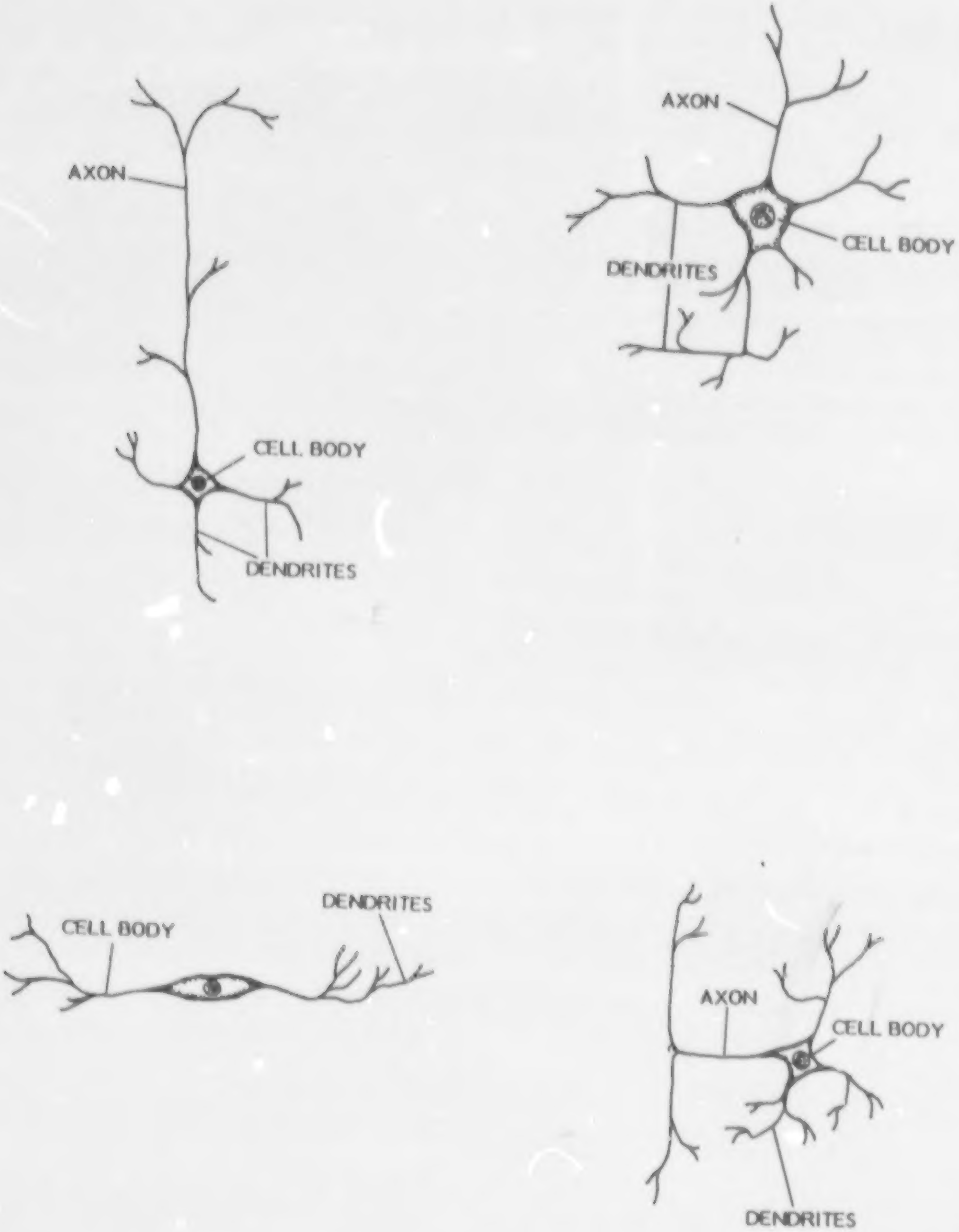
AXON
CELL BODY
DENDRITES
AXON
CELL BODY
DENDRITES
CELL BODY
DENDRITES
AXON
CELL BODY
DENDRITES

Fig. 4A. Types of neurons

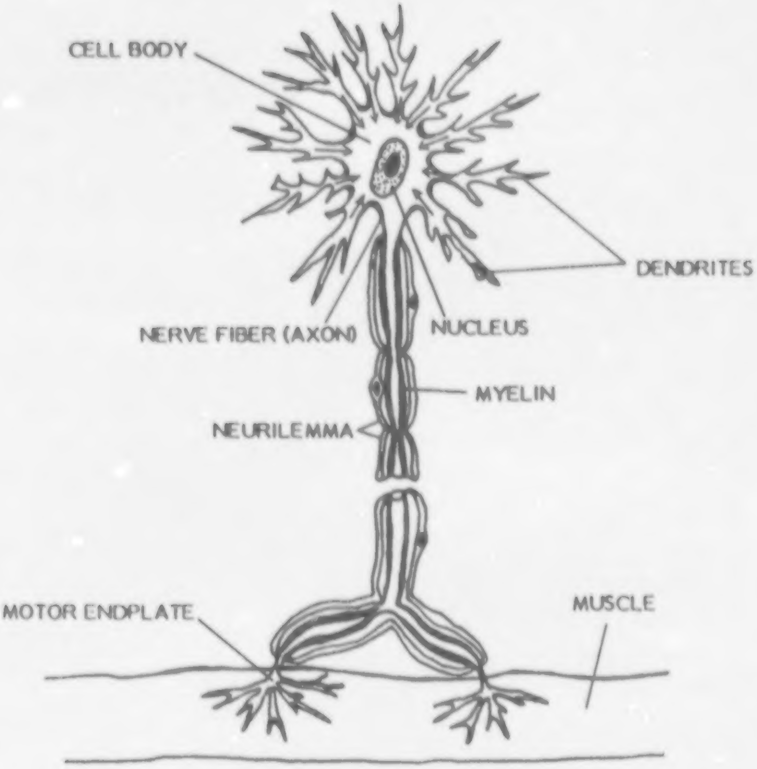
CELL BODY
DENDRITES
NERVE FIBER (AXON)
NUCLEUS
MYELIN
NEURILEMMA
MOTOR ENDPLATE
MUSCLE

Fig. 4B. Motor neuron

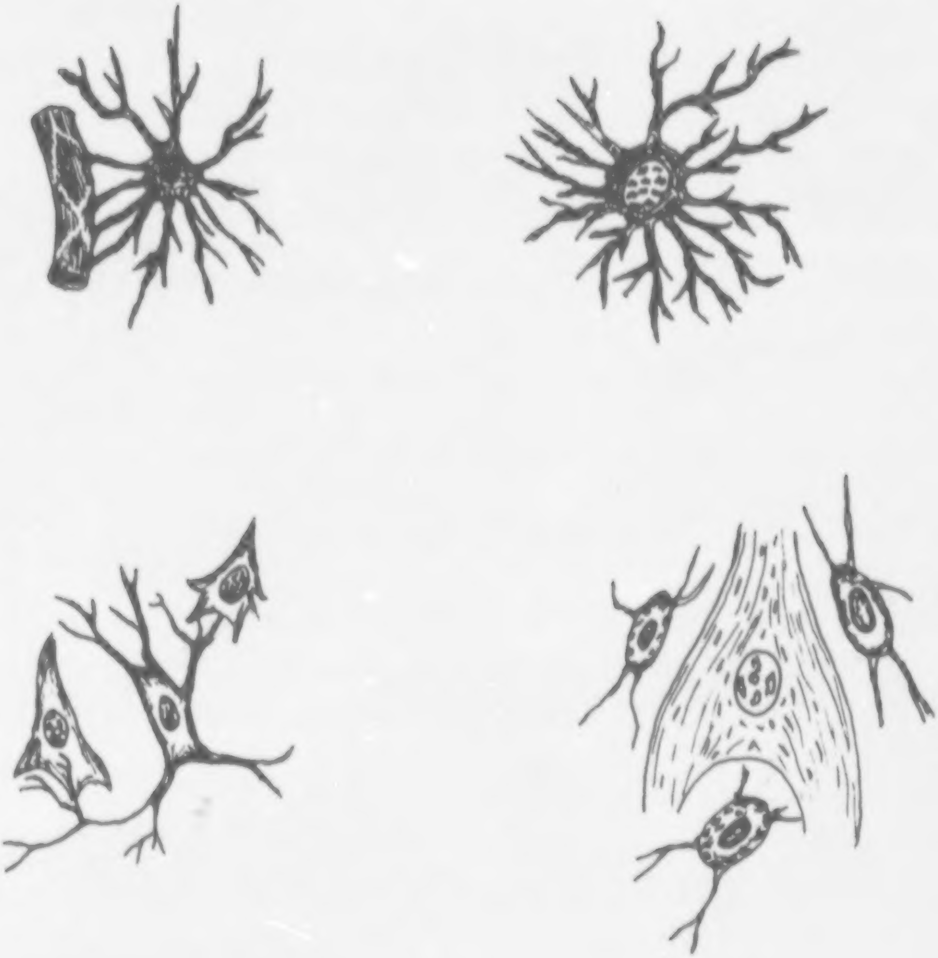

Fig. 5. Types of neuroglia

sound of the alarm clock. Impulses from the brain carried by motor neurons to the arm and hand cause the person to move to turn off the alarm in response to the initial stimulation.

As impulses travel over nerve pathways, many neurons are involved. The cytoplasmic extensions of neurons do not actually touch one another. Rather, there is a small space between the dendrites of one neuron and the axon of another. This space is called a **synapse** or a **synaptic gap**. Impulses traveling from one neuron initiate an impulse in a second neuron across the synaptic gap. Impulses pass in one direction only.

The actual process is extremely complicated, involving the release of chemicals, and the polarization and depolarization of the cell membrane of neurons to cause the transmission of the impulse.

A **reflex arc** (fig. 6) is another type of impulse conduction route. It takes place without involvement of the brain. It consists of a peripheral point of stimulation and a responding organ. Before we can discuss a reflex arc, we must define some new terms. A **receptor** is the end of the dendrite of a sensory neuron, such as those found in a fingertip. **Effectors** are the muscles or glands that respond to stimulation. A **reflex** is the response to impulse conduction over a reflex arc.

Once the receptor (dendrite of sensory nerve) is stimulated, the impulse passes through the dendrites, cell body, and axon. It crosses the synapse to the connecting neuron or interneuron. There the impulse is either inhibited, rerouted, or transmitted. If transmitted, it passes through the interneuron and crosses the synapse to the motor neuron. The impulse travels through the motor neuron to the effector (muscles or glands), and the response takes place. Usually, more than one sensory neuron and one motor neuron is involved.

Reflex actions are involuntary and often unconscious. They happen so quickly, they can bring about a protective response before danger or pain is perceived. For example, the eye blinks several times a minute to keep its surface clean and moist. If the eye is threatened by an approaching object, it blinks before you actually see the object. You cough or sneeze when foreign objects enter or lodge in the nose or throat. You move a foot from a tack before you recognize the tack. In general, reflex arcs are protective mechanisms and help the body to maintain itself in varying environments.

Sense of Hearing

The ear is a sensory organ. It helps us to be aware of our surroundings through hearing. It consists of three regions—the external ear, the middle ear, and the inner ear (fig. 7). When we think of ears we think of the external ear, which is made up of the projecting part called the auricle or the pinna. This part collects and directs sound waves into the auditory canal, or meatus. The canal leads from the outside of the ear and transmits sound waves to the tympanic membrane of the middle ear.

The middle ear includes the tympanic membrane (eardrum), the eustachian tube, and the ossicles. The tympanic membrane covers the inner end of the auditory canal and forms the lateral wall of the tympanum or middle ear. Contained in the tympanum are the three ossicles, or tiny bones. Their names refer to their shape: the hammer (malleus), the anvil (incus), and the stirrup (stapes). The malleus attaches to the tympanic membrane, the incus attaches to the malleus and the stirrup, which in turn attaches to the oval window. The oval window is a membrane-covered opening between the middle ear and inner ear.

The eustachian tube connects the middle ear to the nasopharynx. Its purpose is to equalize air pressure on the tympanic membrane. Without the eustachian tube, changes in air pressure would cause pain and impair hearing. You notice pressure on the eardrum in changes in altitude. Yawning or swallowing helps to equalize pressure by causing air to enter or leave the middle ear by way of the eustachian tube.

The inner ear is called the labyrinth (which means maze, or intricate communicating passages). The three parts of the labyrinth are the vestibule, the cochlea, and the semicircular canals. The vestibule serves as an entryway to the cochlea and the semicircular canals. The oval window connects the middle ear and the vestibule of the inner ear. The cochlea contains receptors which, when stimulated, transmit nerve impulses to the brain. The skull is modified to house and protect the middle and inner ear.

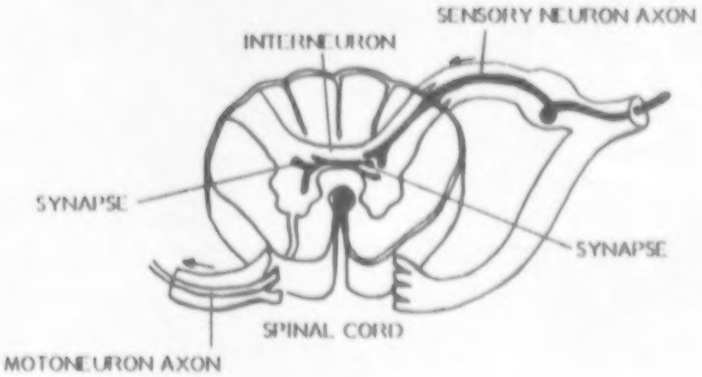
SENSORY NEURON AXON
INTERNEURON
SYNAPSE
SYNAPSE
SPINAL CORD
MOTONEURON AXON

Fig. 6. Reflex arc

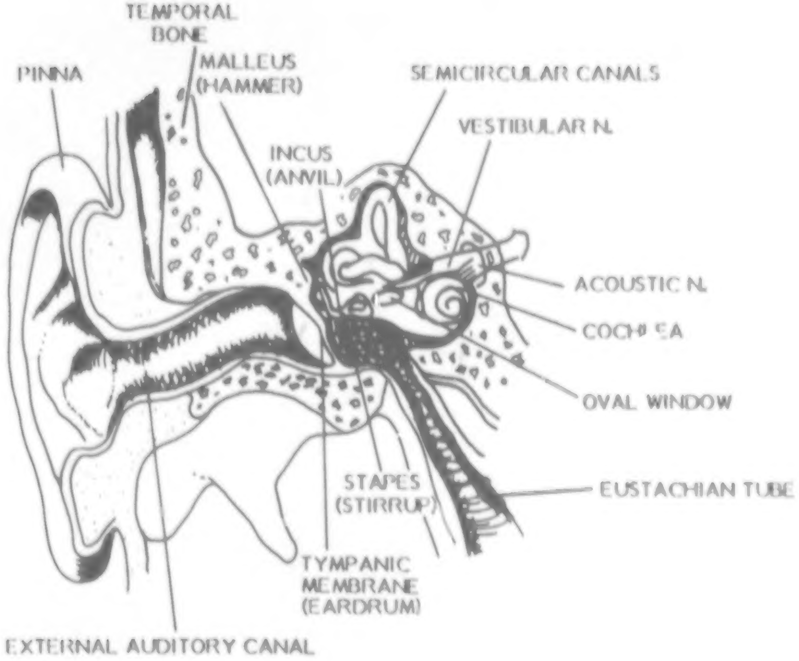
TEMPORAL BONE
PINNA
MALLEUS (HAMMER)
SEMICIRCULAR CANALS
VESTIBULAR N.
INCUS (ANVIL)
ACOUSTIC N.
COCHLEA
OVAL WINDOW
EUSTACHIAN TUBE
STAPES (STIRRUP)
TYMPANIC MEMBRANE (EARDRUM)
EXTERNAL AUDITORY CANAL

Fig. 7. Parts of the ear

The semicircular canals of the inner ear are concerned with equilibrium or balance. There are three canals, which are looped tubes connected to the vestibule. They are at right angles to each other and at 45o angles from the midline of the head. The third canal is horizontal and at a right angle to the other two canals (fig. 8).

Also concerned with balance are two fluid-filled sacs found in the vestibule of the ear—the utricle and saccule—which are lined with hair cells. They contain tiny unattached otoliths. When the head is tilted, the otoliths move about in response to gravity and strike the extensions of the hair cells. This stimulates nerve endings which transmit impulses to the brain by means of the auditory nerve. There the impulses are interpreted to tell us our position.

In order to hear, then, sound waves must be transmitted through the parts of the ear in succession until the auditory nerve is stimulated. The sound waves enter the external auditory canal. They contact the tympanic membrane and cause it to vibrate. This vibratory motion causes the ossicles to move because the malleus attaches to the tympanic membrane. As the ossicles move, they cause the membrane covering the oval window to vibrate. This vibration causes pressure waves in the liquid of the cochlea. The nerve centers in the cochlea are stimulated by these waves and transmit impulses to the hearing center of the brain by the auditory nerve where the impulses are interpreted as sound.

The ability to hear is vital to communication and interaction. We listen, to learn and to find out what others think. It is also important to hear to judge distance and to be aware of factors in our environment through sound.

Sense of Sight

The eye is an almost round structure, but only a small fraction of it shows. The majority of the eye is recessed in, and protected by, a cavity in the skull. Thus, it is almost surrounded by bone. There are openings in the back of the eye socket for nerves and blood vessels into and out of the eye. Attached to the bones and to the outside of the eyeball are the six intrinsic eye muscles that make movement of the eyeball possible.

The eyeball itself is made up of three separate layers (fig. 9). The outer layer consists of the sclera and the cornea. The **sclera** is a tough, protective white coat that covers the surface of the eye. It is "the white of the eye." The **cornea** is a continuation of the sclera that covers the front of the eyeball (the pupil and iris). It is colorless and transparent. Light rays enter the eye through the cornea. Thus, clouding or scanning of the cornea would decrease the amount of light that could enter the eye and impair sight.

The second layer of the eyeball is the **choroid**. It is pigmented and contains many blood vessels. The front of the choroid layer is the iris of the eye. This is the best-known part of the eye because it is the colored portion. The color of one's eye depends on the kinds and amounts of pigment present in the iris. Large granules of blue pigment are found in the layer toward the back. Melanin is a dark pigment that may or may not be present in the front layer of the iris. If melanin is present, the color of the iris will be gray, green, brown, or black depending on the amount of pigment present. If melanin is absent, the iris will be blue. At the center of the iris is an opening called the pupil, which allows light to enter the eye. Just behind the pupil and the iris is the lens, held in place by an intrinsic muscle, the ciliary muscle.

The intrinsic eye muscles are found within the eye itself. The ciliary muscle is a part of the ciliary body. The ciliary body is an extension of the choroid. The ciliary muscle controls the shape of the lens to focus light rays on the retina. The iris is between the cornea and the lens and is made of circular and radial smooth intrinsic muscle that gives it a ringlike shape. As the circular and radial muscle contract and relax, the size of the opening of the iris, the pupil, increases and decreases. The muscle action is stimulated by light. In bright light, the pupil becomes smaller as a result of the contraction of the circular muscles. To adjust to dim light, the radial muscles contract and increase the size of the pupil. This muscular activity is a reflex action and is often used to determine the activity of the autonomic nervous system.

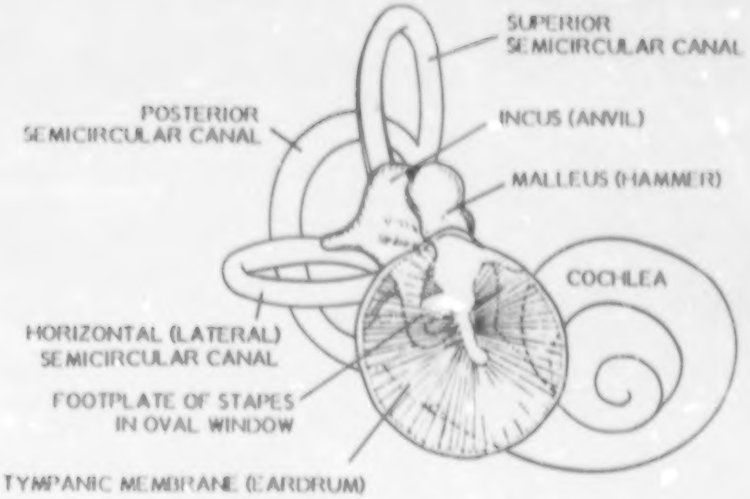
SUPERIOR SEMICIRCULAR CANAL
POSTERIOR SEMICIRCULAR CANAL
INCUS (ANVIL)
MALLEUS (HAMMER)
COCHLEA
HORIZONTAL (LATERAL) SEMICIRCULAR CANAL
FOOTPLATE OF STAPES IN OVAL WINDOW
TYMPANIC MEMBRANE (EARDRUM)

Fig. 8. Semicircular canals

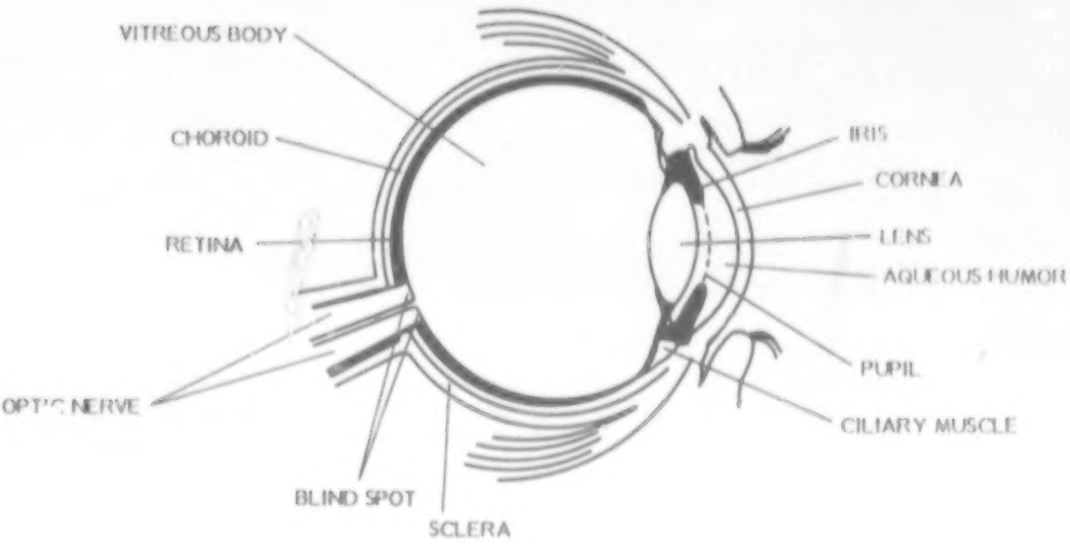
VITREOUS BODY
CHOROID
RETINA
OPTIC NERVE
BLIND SPOT
SCLERA
IRIS
CORNEA
LENS
AQUEOUS HUMOR
PUPIL
CILIARY MUSCLE

Fig. 9. Parts of the eye

The third layer of the eye is the **retina.** It lines the inner surface of the eye up to the ciliary body and contains the nerve cells and receptors that make vision possible.

The receptors in the retina are called rods and cones. The **rods** are sensitive to dim light and function in night vision. They make it possible for us to distinguish shapes and shades of color in light and dark. The **cones** are stimulated by bright light and are responsible for detailed vision and color perception. The nerve fibers of the receptors (rods and cones) all pass across the inner surface of the retina and unite at the posterior part of the eye to form the optic nerve. The point at which these receptors converge contains no rods or cones. It is called the "blind spot" because no image can be perceived at this site.

The interior of the eyeball is a cavity divided into two portions by the lens. The portion of the cavity behind the lens is filled with a gelatinous fluid, the vitreous humor. The **vitreous humor** helps the eyeball to retain its shape and holds the retina in place. In front of the lens is a fluid called the **aqueous humor.** It helps to maintain the shape of the cornea and also transports materials from the blood to the eye.

The lens itself is a biconvex, disc-shaped crystalline body that constantly adjusts its thickness to focus light rays on the retina.

The aqueous humor, vitreous humor, lens, and cornea are the refracting media of the eye. That is, light rays are refracted as they pass through them to strike the retina.

The accessory parts of the eye are those parts that are not directly involved with vision but are necessary for the functioning and protection of the eye. Among these is the lacrimal apparatus, which produces and drains tears. The lacrimal gland is located lateral and superior to the eyeball in the orbital cavity. It produces tears which keep the eyeball moist at all times. The tears are made up of water with salt and mucus. They also contain a weakly germicidal enzyme called lysozyme. There are two lacrimal ducts at the inner edge of each eyelid that lead into the nasal cavity. These carry excess tears into the nasal cavity. Most of the tears evaporate from the eye. When excess tears are produced, as may happen with pain or emotional stress, they overflow the lower lid.

The eyebrows are made up of coarse hairs that protect the eye from dirt, foreign particles, and bright light. The eyelashes fringe the eyelids and also protect the eye from foreign particles. The eyelids are folds of tissue that close reflexively if an object nears the eye, thus protecting the eye from harm.

The conjunctiva is a transparent mucous membrane that attaches to the inner surface of the eyelids and covers the anterior surface of the eyeball.

In summary, vision occurs when light rays enter and pass through the refracting parts of the eye and focus on the retina. The retina in turn translates light energy to nerve impulses that are conducted to the brain by the optic nerve.

The normal eye is able to refract light rays from an object 20 feet away to focus clearly on the retina. Many eyes have errors of vision. One of these is **myopia**, or nearsightedness. This results when light rays focus at a point in front of the retina because the eyeball is too long (fig. 10). **Hyperopia**, or farsightedness, results when the light rays focus at a point behind the retina because the eyeball is too short. Another common vision error is **astigmatism.** This means that the curvature of the lens or the cornea (or both) is uneven, and therefore light rays entering at the uneven point are refracted so that they focus at two points instead of one.

All of these conditions can be corrected with eyeglasses, or lenses placed in front of the eye which correct the error in refraction.

Sense of Smell

The olfactory sense organs, or organs of smell, are located in the upper part of the nasal cavity. There, in the mucous lining, are the olfactory receptors. To produce odors, a substance must be able to give off gaseous particles. If these particles dissolve in mucus of the nasal membrane, the fluid acts chemically on the olfactory receptors. This creates a nerve impulse that travels by means of the olfactory nerve to the brain. There the impulse is interpreted as odor.

People are able to perceive many different odors, and generally are able to identify an odor having once encountered it. Also, people are able to detect faint odors, but

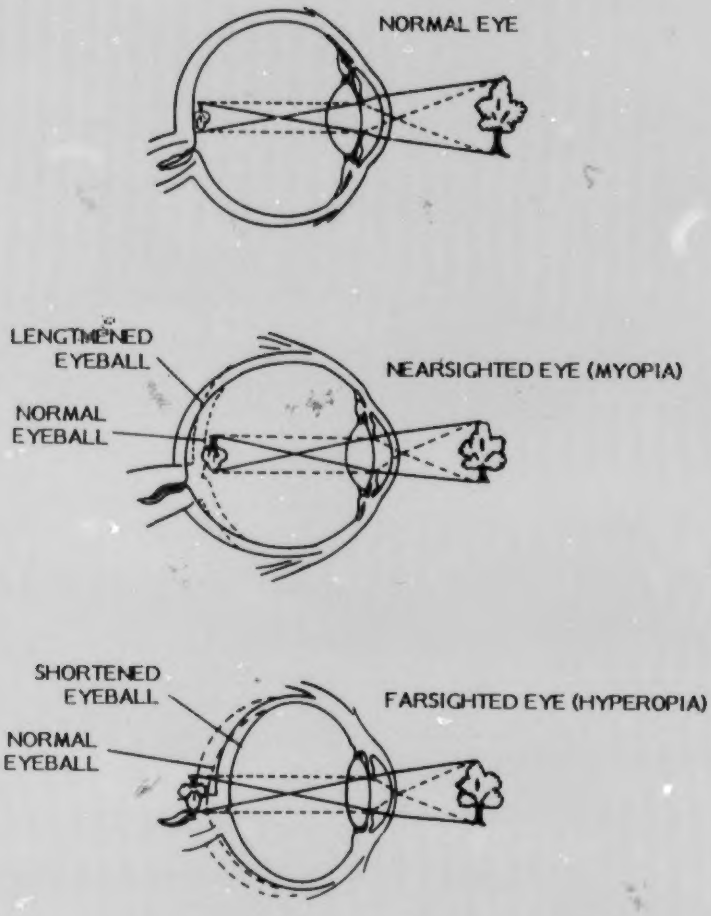
NORMAL EYE
LENGTHENED EYEBALL
NEARSIGHTED EYE (MYOPIA)
NORMAL EYEBALL
SHORTENED EYEBALL
FARSIGHTED EYE (HYPEROPIA)
NORMAL EYEBALL

Fig. 10. Top: normal vision; middle: myopia (nearsighted eye); bottom: hyperopia (farsighted eye)

the olfactory sense tires quickly, and we become less and less aware of odors the longer we are exposed to them. Thus, the wearer of perfume is soon unaware of its presence.

The sense of taste was discussed in Unit 4 in relation to digestion.

Other Senses

The general conception of sense organs is that humans have five—sight, hearing, taste, smell, and touch. Actually, there are several others. Pain is an example. Pain receptors are widely distributed in the body. Almost any sensation, such as pressure, heat, and cold, that is excessively stimulated may stimulate pain receptors at the same time.

Pain receptors respond to a variety of stimuli. The presence of foreign bodies or chemicals may cause pain. An inadequate blood supply, swelling or dilation of a body part, and muscle contraction or spasms are all examples of pain-causing stimuli.

Pain is a defense mechanism. Even though it is uncomfortable, it is a danger warning from the body. Lack of pain in disease can delay diagnosis and treatment and thus lessen chances of recovery.

It is difficult to describe pain, but terms such as burning, stinging, sharp, dull, constant, intermittent, sudden, prolonged, aching, throbbing, and agonizing are used. Since pain is subjective, descriptions will depend on the patient's perception and vocabulary.

Sometimes pain in visceral organs is **referred pain.** This means that the body interprets the pain originating in the viscera as coming from another area instead. The sensory fibers of some skin areas enter the same segment of the spinal cord as the sensory fibers of the organ beneath the skin. Therefore, the pain receptors do not distinguish between the sites. A common example is the pain in the left arm and the skin over the heart in a heart attack. Sensory fibers from the heart and from all of these areas enter the spinal cord between the first and fourth thoracic segments. Referred pain is of great interest in diagnosing disease.

Another type of pain is **phantom pain.** It sometimes occurs when a limb has been amputated. The patient senses pain in the removed limb because sensory nerves that previously received stimulation from the amputated part are stimulated in some other way. If the stimulation is stopped, the pain ceases.

Other senses are hunger, thirst, pressure, temperature, and position. These senses also help us to survive in an ever-changing environment.

Diseases and Disorders

Diseases and disorders of the nervous system and special senses affect many of us. The following list and brief descriptions are meant only to identify some of the most commonly encountered ones.

astigmatism—an irregularity of the curvature of the lens or the cornea of the eye, resulting in faulty vision.

cataract—lens becomes opaque or white.

cerebral palsy—congenital brain disorder, characterized by diverse disorders of muscles varying from weakness to complete paralysis.

conjunctivitis—inflammation of the conjunctiva of the eye.

cerebrovascular accident (CVA)—destruction of brain tissue as a result of hemorrhage from cerebral blood vessels.

encephalitis—infection of the brain.

epilepsy—chronic disorder with abnormality of brain function but without apparent changes in nerve tissues; falling sickness.

glaucoma—impaired vision or blindness as a result of excess intraocular pressure.

hyperopia (hypermetropia)—defect in vision in which light rays focus behind the retina; farsightedness.

meningitis—inflammation of the membranes covering the brain and spinal cord.

motion sickness—nausea, vomiting, and dizziness induced by irregular or rhythmic movements,; such as car sickness or seasickness.

multiple sclerosis—chronic, slowly progressive disease of the central nervous system due to degeneration of axons.

myopia—defect in vision in which light rays focus in front of the retina; nearsightedness.

otitis media—inflammation of the middle ear.

otosclerosis—type of deafness caused by bone changes that prevent normal vibration of the stapes.

paralysis—temporary or permanent loss of function, especially loss of sensation or voluntary motion.

poliomyelitis—an acute viral disease that affects the brain and spinal cord. The virus may destroy motor nerve cells in the spinal cord causing paralysis.

tinnitus—ringing or buzzing sound in the ear.

vertigo—sense of movement of self or surroundings; dizziness.

8

The Urinary System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the urinary system;*
2. *identify the parts of the urinary system;*
3. *give the function of each part of the urinary system;*
4. *give the steps in the formation of urine;*
5. *list the characteristics of urine;*
6. *discuss dialysis and transplants; and*
7. *identify diseases and disorders of the urinary system.*

New Terms and Definitions

active transport—transport of a substance across a membrane; energy is expended in the process.

anuria—failure of the kidneys to secrete urine.

calculus—stone formed within the body, made up of mineral salts.

dialysis—diffusion of a dissolved substance through a semipermeable membrane; also diffusion of blood across a semipermeable membrane to remove toxic materials in cases of impaired kidney function.

enuresis—involuntary urination in persons over 3 years of age; bedwetting.

glycosuria—presence of glucose in urine.

hematuria—presence of blood in urine.

incontinence—lack of voluntary control over urination or defecation.

meatus—a passage or opening; the external opening of the urethra.

micturition—urination.

nephron—unit of the kidney; Bowman's capsule and tubules.

nitrogenous waste—waste products removed in the urine.

peristalsis—progressive wavelike movement that occurs involuntarily in hollow tubes of the body (as in the digestive tract and ureters).

semen—secretion of male sex glands; contains sperm cells.

sphincter—circular muscle surrounding an opening; closes the opening by muscle contraction.

transplant—transfer of tissue or organ from one person to another.

urology—the study of the urinary system.

Functions of the Urinary System

The urinary system has three main functions: (1) to excrete waste products from the blood, (2) to regulate the water balance of the body, and (3) to regulate the acid-base balance of the body. All of these functions help to maintain homeostasis.

Structure of the Urinary System

The parts of the urinary system are the paired kidneys and ureters, the urinary bladder, and the urethra (fig. 1). The kidneys are bean-shaped organs only about 4 1/2 inches (11.25 cm) long and 2 1/2 inches

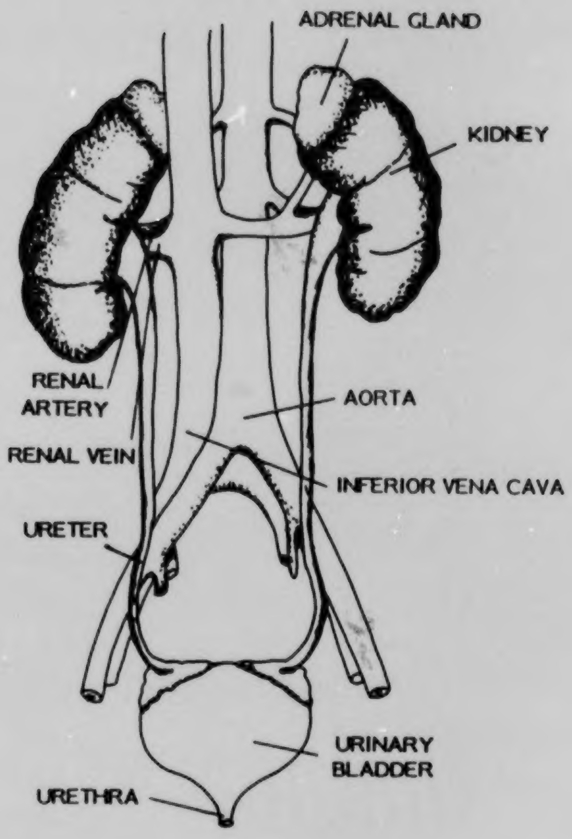
ADRENAL GLAND
KIDNEY
RENAL ARTERY
AORTA
RENAL VEIN
INFERIOR VENA CAVA
URETER
URINARY BLADDER
URETHRA

Fig. 1. Organs of the urinary system

(6.25 cm) wide. Each kidney weighs about 5 ounces. They are reddish brown in color and are located on each side of the spinal column at the level of the twelfth thoracic and first three lumbar vertebrae. They are on the posterior abdominal wall behind the peritoneum and are surrounded by fat and fibrous tissue that helps hold them in place and protects them from injury. The kidneys are also protected by an outside sheath or capsule of tough connective tissue.

The bean shape results from a concave notch on the medial side of the kidney called the hilum. It is at the hilum that large blood vessels and the ureters enter the kidney.

The interior of the kidney is divided into the outer portion or cortex, and the inner portion or medulla (fig. 2). The medulla is made up of wedge-shaped sections called pyramids. The narrow end of each pyramid ends in the calyx of the pelvis of the kidney. The cortex or outer portion extends between each pyramid, forming renal columns.

The **ureters** are tubes, 10 to 12 inches long and about 1/2 inch in diameter, that extend from the pelvis of the kidney to the urinary bladder. They are also located behind the peritoneum. They enter the posterior wall of the urinary bladder at a sharp angle which inhibits the backflow of urine. However, there is no valve or sphincter between the ureters and the urinary bladder. Peristalsis moves the urine through the ureters to the urinary bladder.

The **urinary bladder** is a muscular bag in which urine collects. It lies in the pelvic cavity behind the pubic bones. The bladder is lined with a mucous membrane arranged in folds, or rugae, which increases its ability to expand. The functions of the urinary bladder are to serve as a reservoir for urine and to expel urine from the body through the urethra. Urination is also called micturition or voiding.

Urine is formed continuously. The normal amount excreted in a 24-hour period varies tremendously, from about 1,000 ml to 2,000 ml. The amount depends on such factors as fluid intake, diet, activity, environmental and body temperature, age, and blood pressure.

An empty urinary bladder looks like a deflated balloon. However, as it gradually fills, the walls become smooth and it is oval in shape. It has a capacity of about 480 ml, but the urge to urinate usually begins at about 250 to 300 ml. Under normal conditions, if a person drinks a large quantity of fluid, in about 42 minutes enough urine will have collected in the bladder to cause the urge to urinate.

Urination is brought about by a combination of voluntary and involuntary nerve impulses. When the amount of urine in the bladder reaches about 250 to 300 ml, nerves in the bladder are stimulated to send a message to the spinal cord. Parasympathetic nerves transmit a return message to the bladder to urinate. This is a reflex action.

In persons over 3 years of age, after receiving the message to empty the bladder, nerve impulses are sent to the cerebral cortex of the brain, and the urge to urinate is controlled voluntarily. The sphincter around the opening of the urethra is consciously relaxed, and release of urine from the bladder takes place.

Involuntary urination in adults may result from injury to nerves that control the urinary bladder. Also, unconsciousness, bladder disease, and even emotional stress may cause involuntary urination.

In babies and children up to 2 years of age, urination is involuntary. As the bladder fills, the message to the spinal cord is followed by a return message to the bladder which then empties reflexively. As children grow older, training to condition the reflex and to control urination voluntarily is possible.

Enuresis (bedwetting) is involuntary urination in a person over 3 years. It can be caused by many factors, including local irritation of the bladder and urethra or emotional instability.

The **urethra** is a tube extending from the anterior part of the urinary bladder to the outside of the body. It is lined with mucous membrane. The outside opening is called the urinary meatus. In females, the urethra is about 1/4 inch in diameter and only 1 to 1 1/2 inches long. It originates behind the pubic bone but in front of the vagina. In males, the urethra is about 8 inches long. It passes through the prostate gland, then extends through the penis to the urinary

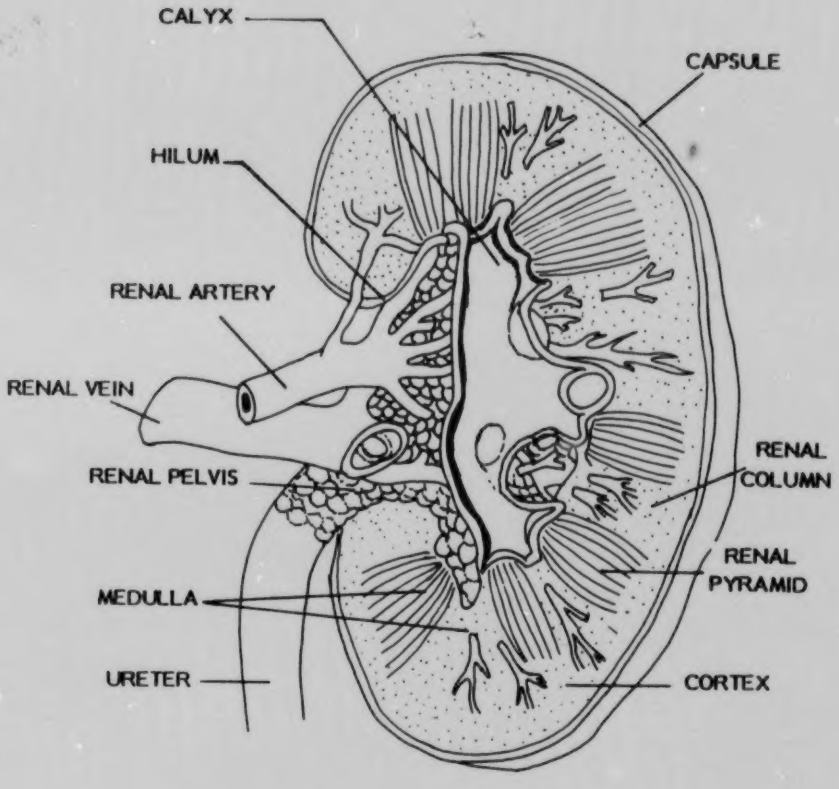
CALYX
CAPSULE
HILUM
RENAL ARTERY
RENAL VEIN
RENAL PELVIS
RENAL COLUMN
RENAL PYRAMID
MEDULLA
URETER
CORTEX

Fig. 2. Inside structure of the kidney

meatus. The urethra in males is the passageway for semen as well as urine. In females, the urethra only discharges urine.

A study of the microscopic structure of the kidney reveals the complexity and efficiency of its function. It is made up of millions of tiny tubules called **nephrons** (from "nephros," the Greek work for kidney). Each tubule has a cup-shaped mouth called **Bowman's capsule.** Fitted into Bowman's capsule is a complex network of capillaries called a **glomerulus.** The glomerulus and Bowman's capsule together form a unit, the **renal corpuscle** (fig. 3). These are so small that there are about 2 1/2 million renal units in the kidneys.

The remainder of the nephron is a tiny tubule divided into definite segments. Each segment has a specific function. The proximal segment (closest to Bowman's capsule) is extremely twisted or convoluted. It contains a layer of epithelial cells bearing microvilli which increase its surface area. The next portion of the tubule is the loop of Henle (named for T. G. J. Henle). This portion is "U"-shaped. It joins the distal tubule which is also convoluted. This last portion of the distal tubule joins the distal tubes of other nephrons to empty into a collecting tubule.

Now keep these structures in mind as we discuss the formation of urine. Recall that the functions of the urinary system are to excrete waste products from the blood, to regulate the body's water and electrolyte balance, and to regulate the acid-base balance of the body. It is in the nephrons of the kidney that these things take place.

Blood flows to the kidneys by means of the renal arteries. As blood leaves the heart through the aorta, 20 to 25 percent goes to the kidneys. That is, about 1,200 ml of blood flows to the kidneys each minute. From the renal arteries the blood flows through progressively smaller arteries to arterioles and finally to the capillaries of the glomeruli. This sudden decrease in the size of blood vessels causes an increase in blood pressure in the glomeruli. This in turn causes the water and solutes from the blood to filter through the glomerular walls and the parietal layer of Bowman's capsule. The water and solutes make up the glomerular filtrate. Large particles such as blood cells do not filter out of the capillaries because of their size, nor do protein molecules normally pass through the capillary walls. The blood becomes temporarily thicker and more viscous because of the water loss.

In the proximal tubules, about 95 to 98 percent of the water and electrolytes, such as sodium ions, and all of the nutrients (glucose and amino acids) from the glomerular filtrate are reabsorbed into the capillaries. The remainder of the water and solutes moves into the loop of Henle. Here some sodium chloride moves from the tubules to the interstitial fluid of the medulla of the kidney by active transport. Next, the remaining fluid moves into the distal and collecting tubules. Some water and a small amount of sodium is reabsorbed into the capillaries. The amount of water reabsorbed from the distal tubule and collecting tubules is controlled in part by the antidiuretic hormone (ADH) produced by the posterior pituitary. Aldosterone produced in the adrenal cortex also helps to maintain the body's water balance and regulates the reabsorption levels of sodium and potassium.

Finally, the cells of the distal tubule secrete varying quantities of hydrogen ions and ammonia which regulate the pH of the urine and in turn the acid-base balance of the body.

The capillaries of the distal tubules merge with larger venules, then veins; and finally the blood, with water, nutrients, and ions from the nephrons, leaves the kidney by means of the renal vein to flow through the body.

The fluid in the distal tubule containing those solutes not returned to the blood, and the ions secreted by the tubule, form the urine. Briefly put, urine is formed in the nephrons by three processes—filtration, reabsorption, and secretion. The distal tubules of several nephrons flow into a straight tube called a collecting tubule. These tubules join progressively larger tubules until one large tube opens into a calyx in the pelvis of the kidney. The pelvis is a funnel-shaped sac that actually forms the upper end of the ureter. Thus, urine flows from the nephrons through collecting tubules to the ureters. From the ureters, urine flows to the urinary bladder.

It is usually in the pelvis of the kidney that **kidney stones** (or calculi) are formed, although they may occur in the ureter, bladder, or urethra. These are concretions

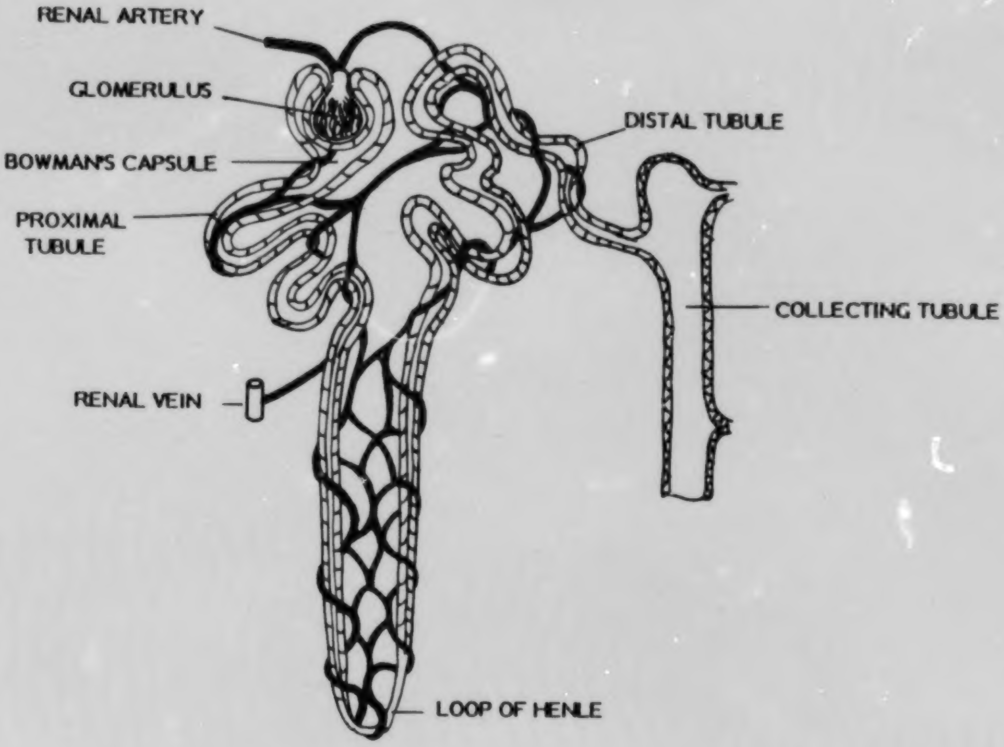
RENAL ARTERY
GLOMERULUS
BOWMAN'S CAPSULE
PROXIMAL TUBULE
RENAL VEIN
DISTAL TUBULE
COLLECTING TUBULE
LOOP OF HENLE

Fig. 3. Renal corpuscle

formed of urinary salts. They can cause great pain, blood in the urine, and retention of urine in the pelvis of the kidney.

In summary, the end products of metabolism such as urea, uric acid, and creatine are retained as waste solutes with water and are removed from the blood by the kidneys to form urine. The remaining solutes and about 95 percent of the water are returned to the capillaries after filtration. The capillaries, venules, and veins finally flow into the renal vein. The kidneys are such efficient organs that they actually filter the entire volume of the blood about sixty times each day.

Normal urine is about 95 percent water in which solids are dissolved. It is yellow to amber in color and has a characteristic odor. Normal organic solutes are nitrogenous wastes such as urea, uric acid, ammonia, creatine, and creatinine. Also present are inorganic substances such as sodium chloride, potassium chloride, calcium, magnesium, and phosphorus. Urine is usually clear and slightly acidic. A urinalysis is a common diagnostic procedure. Routine tests determine the presence of abnormal constituents such as glucose, protein, acetone, bile, and urobilin. Microscopic studies determine the presence of abnormal components such as blood cells, bacteria, or crystals.

Diseases and Disorders

Dysfunction and disease of the urinary system can cause serious health problems. The following list and brief descriptions are meant only to identify some of the most common.

cystitis—inflammation of the bladder.

dysuria—painful urination; a symptom of various disease conditions.

edema—condition in which body tissues contain an excessive amount of tissue fluid; swelling.

nephritis (Bright's disease)—severe inflammation of the kidneys.

oliguria—less than normal amount of urine formed.

polycystic disease—kidney contains many cystlike dilations as a result of deformity of nephrons; inherited disorder.

polyuria—excessive amount of urine formed.

pyelitis—inflammation of the pelvis of the kidney.

uremia—condition in which nitrogenous wastes normally excreted by the kidney are retained in the blood.

urethritis—inflammation of the urethra.

Hemodialysis and Transplants

Two procedures to prolong the lives of persons with kidney disease have become common in the past generation—hemodialysis and transplants.

Hemodialysis is a procedure for the mechanical removal of waste materials from the blood. It is used to cleanse the blood of patients whose kidneys are defective. The patient is connected to a kidney machine. Blood from the patient's radial artery is passed through tubing to one side of a semipermeable membrane, and continually washed in a solution that approximates blood components. The wastes pass through the membrane into the bath solution. Only about 500 ml of blood can be cleansed at a time. The clean blood is returned to the body. There are many disadvantages to hemodialysis, but for critically ill patients the advantages outweigh the problems. No artificial kidney that can be implanted has yet been devised.

Kidney transplants have been used rather extensively. A healthy kidney from one person is transplanted into the body of a person with critical kidney disease. Such transplants are most successful between persons with identical or similar genetic backgrounds. Transplants between identical twins are ideal, but unfortunately such circumstances are rare. Family members are often used as donors.

A serious problem with transplants is that the body often responds to a transplant as foreign protein and produces antibodies to destroy the transplant. This is called **tissue rejection.** Drugs which suppress the body's ability to produce antibodies or "immune suppressants" are sometimes given to reduce the rejection.

Another problem with kidney transplants is that often the condition that initially caused kidney failure still exists, and thus the transplanted organ is unable to function.

The Living Bank is a national organization that provides information about giving and receiving organs for transplant.

9

The Reproductive System

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the reproductive system;*
2. *identify parts of the male and female reproductive systems;*
3. *give the functions of the reproductive parts;*
4. *list hormones that control activities of the reproductive organs;*
5. *review the sequence of events of menstruation;*
6. *define* ***menarche*** *and* ***menopause****;*
7. *discuss lactation;*
8. *identify secondary sex characteristics;*
9. *discuss fertilization and major events in embryonic development; and*
10. *recognize descriptions of diseases and disorders of the reproductive system.*

New Terms and Definitions

breech presentation—in delivery of a child, some part other than the head is first to emerge from the birth canal, most commonly the buttock of the fetus, or a foot.

cesarean section—removal of a fetus by means of incision into the uterus, usually by way of the abdominal wall.

copulation—sexual intercourse.

embryo—early or developing stage of any organism; in humans, the second through the fifth week of uterine life.

episiotomy—incision of perineum at the end of the second stage of labor to avoid laceration of perineum and to facilitate delivery.

fertilization—union of an ovum with a sperm cell to produce a zygote.

fetus—latter stages in developing child in uterus from about the third month of pregnancy to birth.

genitalia (genitals)—reproductive organs.

gestation—the time that the embryo or fetus remains in the uterus (280 days).

hormone—secretion of a ductless gland that regulates the function of other organs.

hysterectomy—surgical removal of the uterus.

menarche—beginning of menstruation.

menopause—cessation of menstruation.

menstruation—cyclic uterine bleeding that normally occurs at about 4-week intervals in the absence of pregnancy; controlled by hormones.

ovulation—periodic discharge of ovum from ovary.

ovum—female reproductive cell; egg cell.

parturition—act of giving birth to young.

reproduction—process by which offspring are produced.

semen—secretion of male reproductive organs containing sperm cells and secretions from accessory reproductive glands.

spermatozoon—male reproductive cell; sperm cell.

vasectomy—removal of a segment of the vas deferens to produce sterility in males.

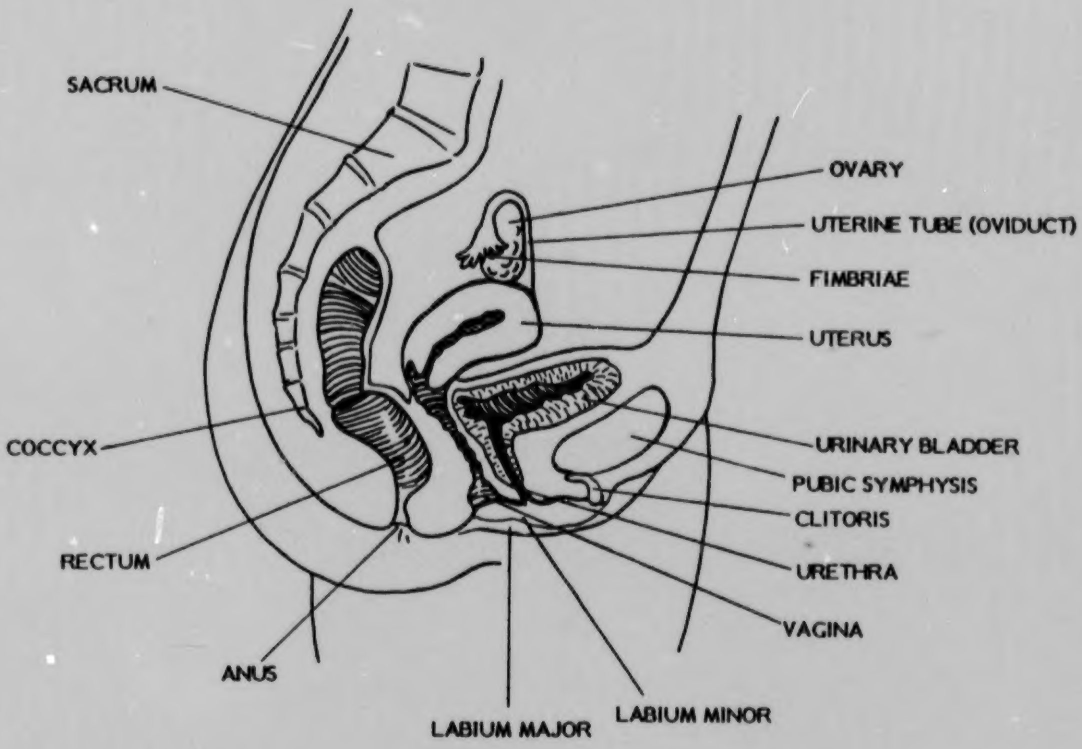
SACRUM
OVARY
UTERINE TUBE (OVIDUCT)
FIMBRIAE
UTERUS
COCCYX
URINARY BLADDER
PUBIC SYMPHYSIS
CLITORIS
RECTUM
URETHRA
VAGINA
ANUS
LABIUM MINOR
LABIUM MAJOR

Fig. 1. Female reproductive parts

zygote—cell produced by the union of an egg cell with a sperm cell.

Reproduction is the process by which offspring are produced. Thus, the primary function of the reproductive system is the maintenance of the species. The function of all other body systems is the maintenance of the individual.

Simple life forms may reproduce asexually by simple cell division, but in higher forms of life, including human beings, there is a separation of sexes into male and female. Males produce male sex cells (spermatozoa), and females produce female sex cells (egg cells or ova). Ova and spermatozoa unite in a process called fertilization to produce a new cell called a zygote. A zygote is the first cell of a new individual.

Sex cells are produced by a complex type of cell division in the ovaries and testes, called meiosis. Each mature sex cell carries one-half of the genetic material (chromatin) required for a new individual. Thus, at fertilization each parent contributes exactly half of the hereditary traits for the new zygote. In this way, the new individual will be different from each parent but have half the hereditary characteristics of each.

Female Reproductive System

Ova are produced in the female reproductive system. The internal parts of the system are the ovaries, oviducts (uterine tubes), uterus, and vagina (fig. 1). The ovaries are paired organs located on either side of the uterus in the upper part of the pelvic cavity. They are homologous to the testes in males. The ovaries are small, almond-shaped bodies about 4 cm (1 1/2 inches) long and weighing about 3 gm each. Each ovary contains 100,000 to 400,000 immature ova at birth. After puberty, the ova develop individually and are released, usually one at a time, from the ovary in a process called ovulation. Of the thousands of immature ova, only 300 to 400 will mature and be released from the ovary. The rest degenerate, die, and are reabsorbed.

The function of the ovaries then is to produce ova. A second function is to produce female hormones called estrogen and progesterone.

The oviducts, also called Fallopian tubes or uterine tubes, are a pair of ducts that lead from a point near the ovaries to the uterus. The ducts are about 11 cm (4 1/2 inches) long, and open into the uterus. The ovarian end of the duct is in contact with, but not attached to, the ovary. This end is somewhat funnel-shaped and has many fringelike extensions called **fimbriae.** When an ovum is released from the ovary, the fimbriae function like tentacles to draw the egg cell into the oviduct. It is in the upper third of the oviduct that fertilization of the ovum usually occurs.

The oviducts have three layers, as does the uterus. They are the mucous layer, the smooth muscle layer, and the inner mucous layer. The inner layer is ciliated. Peristalsis of the smooth muscle layer and currents set up by the cilia help to move the egg cell through the oviduct. The lining of the oviduct is continuous with that of the uterus and vagina. Since the vagina opens to the exterior of the body, there is an open passage from the outside of the body into the peritoneal cavity. Such a passage makes it possible for bacteria to enter the peritoneal cavity from the female reproductive tract. In males, no such pathway exists.

The functions of the oviducts are to provide a passageway for the ovum to move from the ovary to the uterus. A second function is to provide a place for fertilization of the ovum.

The uterus (or womb) is the organ that contains and nourishes the developing embryo. The nonpregnant uterus is a small, hollow, pear-shaped, muscular organ only about 7.5 cm (3 inches) in length and 5 cm (2 inches) across at the widest part. It is located in the pelvic cavity. The rectum lies behind the uterus, and the urinary bladder is in front.

The uterus is divided into two regions, the upper and the lower. The oviducts enter the uterus at the upper outer angles at each side. The top bulges upward to form the fundus of the uterus. The lower portion (or cervix) narrows, constricts, and opens into the vagina (fig. 2).

The uterus is characteristically thick-walled. The walls are made of three distinct layers. The outer layer is called the perimetrium (serous layer), the middle layer is the myometrium (smooth muscle layer), and the inner layer is the endometrium. The myometrium is made of smooth muscle, which makes possible the great change in

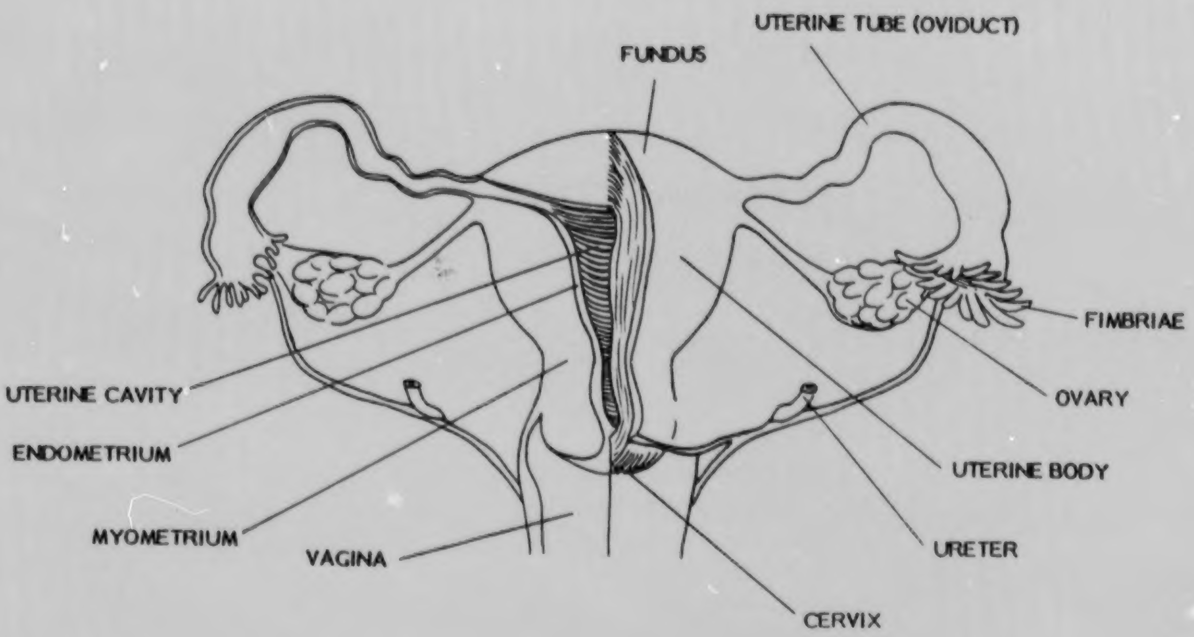
UTERINE TUBE (OVIDUCT)
FUNDUS
FIMBRIAE
OVARY
UTERINE BODY
URETER
CERVIX
UTERINE CAVITY
ENDOMETRIUM
MYOMETRIUM
VAGINA

Fig. 2. *Section of uterus and female reproductive parts*

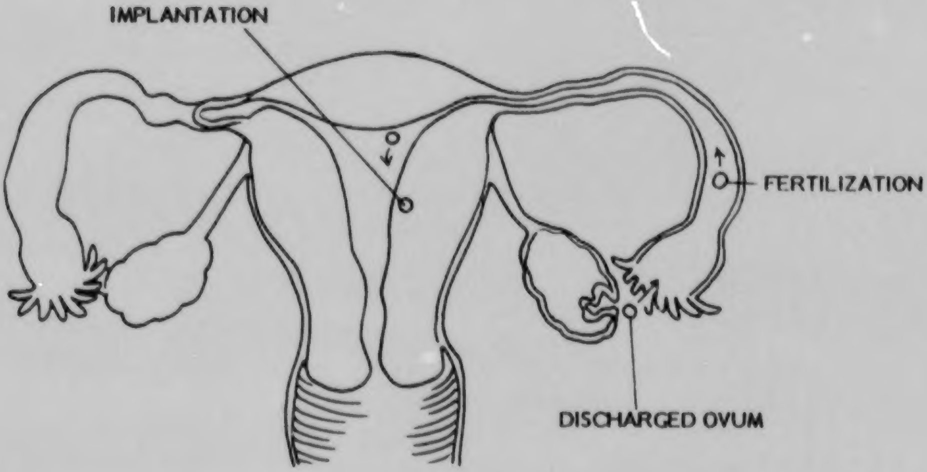
IMPLANTATION
FERTILIZATION
DISCHARGED OVUM

Fig. 3. *Migration of ovum from ovary to uterine wall*

size needed during pregnancy. The endometrium, or inner mucous layer, is specialized in that it is the top two layers of cells of the endometrium that are lost during menstruation.

The functions of the uterus are menstruation, pregnancy, and labor. In pregnancy, it is the uterus in which the embryo is implanted and remains for 40 weeks of development and growth. Then, at the end of pregnancy, the mature fetus is expelled by the powerful, rhythmic contractions of the uterine wall. In menstruation, it is the endometrium that sloughs away, with bleeding from torn uterine vessels.

The vagina is a tube that extends from the cervix to the exterior of the body. It lies behind the urinary bladder and in front of the rectum (fig. 2). The vagina is usually about 10 to 15 cm (4 to 6 inches) long and extends at an approximately right angle downward and forward from the cervix. The vaginal walls have a membranous lining and muscle layer capable of great distension for childbirth. The walls are normally folded to form a collapsed tube.

One function of the vagina is to serve as an excretory duct for uterine secretions and menstrual flow. It also serves as the lower part of the birth canal. A third function is to receive seminal fluid from the male in copulation.

The external genitalia of the female reproductive system are collectively called the **vulva** or pudendum. The parts are the mons pubis, labia majora, labia minora, clitoris, Bartholin's glands, vaginal orifice, and urinary meatus.

The mons pubis is a rounded pad of fatty tissue just over the pubic symphysis. Short, curly hair covers the mons at puberty. The labia majora are longitudinal folds of skin with underlying fat that form the lateral borders of the vulva. They extend backward from the mons toward the anus. The labia minora are a pair of small folds of skin that lie between the labia majora and unite anteriorly. The clitoris is a small structure of erectile tissue that is behind the junction (anterior) of the labia minora. It is homologous to the penis in males. The urinary meatus is the opening of the urethra. It is found between the clitoris and the vaginal orifice. The vaginal orifice is the opening to the exterior of the vagina found posterior to the urinary meatus.

Bartholin's glands (vulvovaginal glands) are tiny paired glands that secrete a lubricating fluid. They are located on either side of the vaginal opening and their ducts open into the labia minora. Bartholin's glands in females correspond to the bulbourethral glands in males. These glands can be clinically important because they are sometimes infected, particularly with gonococci, which causes gonorrhea.

The perineum is the pelvic floor. It is a muscular area between the thighs and buttocks. It is bound by the pubic symphysis and coccyx from anterior to posterior, and laterally by the ischial tuberosities. It contains the anus and external genitalia. The perineum is of great importance in childbearing. Sometimes tissues do not expand adequately for delivery, and tissues such as the perineal muscle, vaginal epidermis, and even tissues of the rectum may tear. To avoid this, a surgical procedure called an **episiotomy** is done if indicated. An incision is made in the tissue which provides room for delivery with a clean wound that can be neatly sutured in layers after delivery.

The mammary glands are contained in the breasts. They are concerned with reproduction because they secrete milk. The breast is made up 15 to 20 lobes of secretory tissue supported by connective tissue and fat. Each lobe has a duct that empties into the nipple of the breast. The nipple is a rounded projection, surrounded by a pigmented area called the areola. The size of the breasts does not determine the quantity of milk that may be produced.

The function of the mammary glands is the secretion of milk for the nourishment of the newborn and young children.

Preparation of the breasts for lactation is controlled by the hormones estrogen and progesterone. When the placenta is delivered, the estrogen level drops. This lowered level of estrogens stimulates the anterior pituitary to produce lactogenic hormone, or prolactin. Lactogenic hormone then stimulates the mammary glands to produce milk. At the same time, the posterior pituitary produces the hormone oxytocin, which also stimulates the mammary glands to produce milk.

It takes 2 to 3 days after delivery for milk to be produced. In the meantime colostrum is secreted. **Colostrum** is a thin, yellowish fluid secreted by the mammary glands which contains a high concentration of immune bodies, proteins, and calories.

Menstruation refers to the cyclic uterine bleeding that normally occurs at about 28-day intervals in the absence of pregnancy, and the accompanying changes in female hormone concentrations. Menstruation usually begins at about age 13, although there is much variation. The initiation of the menstrual cycle at puberty is called the **menarche.**

Beginning with the first day of menstruation, the following events occur in sequence.

1. Several ovarian follicles containing ova begin to grow and to secrete estrogens.*
2. One follicle matures and moves to the surface of the ovary. This growth and movement take place between the first day of menstruation and the fourteenth day of the menstrual cycle.
3. The follicle wall degenerates and ruptures on about the fourteenth day, and the ovum is released into the pelvic cavity. This is ovulation. Some females experience pain and discomfort at ovulation. The cause is not well understood.
4. After ovulation, the cells of the ruptured follicle grow and are filled with a yellow lipid. The body thus formed in the ovary is called the corpus (body) luteum (golden).
5. The corpus luteum continues to grow for 7 to 8 days. During this time it secretes the hormone progesterone.
6. The ovum by now has entered the oviduct. If sperm cells are present, fertilization may occur. If it does not, the corpus luteum decreases in size, and by the end of fourteen days it disappears. Progesterone production decreases.
7. In the days following ovulation, the endometrium continues to thicken to 4 to 6 mm.
8. The day before the onset of menstruation, the blood supply to the endometrium diminishes, and the endometrial cells begin to die.
9. Menstruation begins. The outer layers of the endometrium (inner uterine lining) slowly slough off. This leaves small bleeding areas. The menstrual flow of blood and bits of tissue normally lasts for about 4 days.
10. After menstruation has stopped, endometrial cells begin to grow and replace those lost. The endometrium is 2 to 3 mm thick by the time ovulation occurs. This growth of endometrium prepares the uterine wall for the implantation of the embryo.

There are two other hormones that influence the menstrual cycle—the follicle-stimulating hormone (FSH) and the luteinizing hormone (LH). These are secreted by the anterior pituitary. As the name indicates, FSH stimulates the production of the ovarian follicles with ova production and the secretion of estrogens. LH also influences follicle growth, presumably causes ovulation, and with FSH brings about the development of the corpus luteum with the secretion of progesterone and estrogens.

In summary, menstruation is a cyclic event that occurs at about 28-day intervals. An ovum is released from the ovary, and the lining of the uterus is prepared for the implantation of a zygote. If fertilization does not occur, the ovum and the uterine lining are discharged. Then the process begins again. All of these functions are controlled by hormones secreted by the pituitary and the ovaries.

The development of female secondary sex characteristics is also controlled by estrogens. These characteristics begin to develop at puberty. Examples are change in voice pitch, development of body hair, skeletal changes including broadening of the pelvic girdle, and fat distribution to the breasts, abdomen, and hips.

The menstrual cycle continues for about 30 to 40 years. Then **menopause,** or a cessation of the menstrual cycle, occurs. It occurs between the ages of 35 and 58. The ovaries no longer respond to FSH and LH to produce ova. The secretion of estrogens and progesterone by the ovaries decreases. The age of reproductivity is over.

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* Estrogen is a broad term for several estrogenic hormones including estradial and the synthetic diethylstilbestrol.

Some women suffer side effects at menopause (also called climacteric). Examples are a sudden feeling of warmth, sweating (hot flashes), headaches, and even mental depression. This is treated with hormone replacement until the body adjusts to the omission of the menstrual cycle.

If fertilization occurs, the menstrual cycle ceases until delivery and then resumes. Lactation may inhibit ovulation for a few months after delivery.

Almost immediately upon fertilization, the zygote begins to grow by cell division (mitosis). It takes 8 to 10 days for the developing embryo to reach the uterus and implant into the lining of the uterine wall (fig. 3). The study of the developing embryo is called embryology.

The placenta is a special structure that forms from the embryonic and maternal tissue. It functions in the exchange of food, gases, and wastes between mother and baby. It also serves as a barrier against bacteria between mother and baby. However, antibodies, some viruses, and the bacterium that causes syphilis may be transmitted from mother to baby across the placental barrier.

Pregnancy lasts for 280 days, or 40 weeks. To calculate the date for delivery, add one year and seven days to the date of the last menstrual period and subtract three months.

From the second through the eighth week of embryonic life, the child is called an **embryo**. From the third month to birth it is called a **fetus**.

If an embryo or fetus is lost during the first 20 weeks of pregnancy, this is called an abortion. Abortion may be spontaneous, which means the pregnancy terminates naturally, or induced, which means the pregnancy is terminated by artificial means.

If the fetus is lost between 20 and 28 weeks, this is called a miscarriage. Great progress is being made in the care of premature infants, and many survive and develop normally after only 7 months of intrauterine life. Of course, optimum chances for survival depend on the full 40 weeks of development.

The development of the embryo is a complex process too intricate for details here. However, the new life begins at fertilization, the embryonic heart begins to beat at about the fifth week of development, and by the end of the fourth month all organs are formed. The embryo then continues to grow until birth (parturition) occurs.

Male Reproductive System

The male reproductive system produces spermatazoa (male reproductive cells), secretes male sex hormones, and introduces sperm cells into the female vagina. The major parts are the testes, containing tubules to deliver sperm cells, ducts outside the testes, glands, and the penis.

The testes are paired oval organs about 4 to 5 mm (1 1/2 to 1 3/4 inches) long. They weigh about 10 to 15 gm each. They are contained in a specialized fold of skin called the scrotum, which is suspended from the perineal region. The scrotum also contains the epididymis and the lower part of the vas deferens.

In embryonic development the testes are found inside the abdominal cavity in the area of the kidneys. About two months before birth they migrate to an opening in the muscular wall of the abdominal cavity, called the inguinal canal, and into the scrotum. The muscles of the abdominal wall then close. Sometimes this inguinal area remains weakened. Then great muscle strain may cause a part of the intestine to push through the weakened spot. This is called a **hernia**, and it is usually repaired surgically.

Sometimes one or both of the testes remain in the abdominal cavity, undescended. This condition is called **cryptorchidism** (crypt = hidden; orchis = testes). Surgery is usually performed early in childhood to place the testes in the scrotum. This is extremely important because undescended testes may cause sterility. The higher temperature inside the abdominal cavity inhibits sperm production. Although body temperature is only 2 or 3 degrees higher than the temperature in the scrotum, this small increase inhibits sperm production.

The functions of the testes are to produce sperm cells and to secrete hormones.

Spermatazoa are produced in the testes from specialized cells called spermatogonia. Mature sperm cells are divided into the head (which contains nuclear material and the

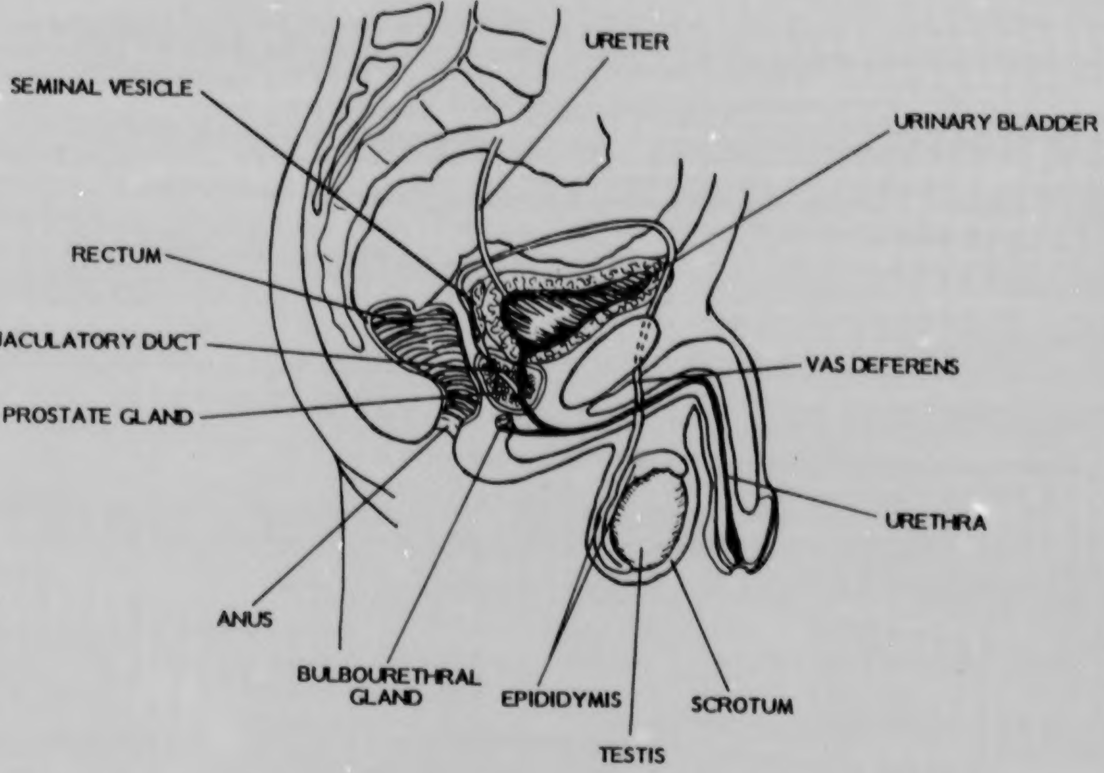
URETER
SEMINAL VESICLE
URINARY BLADDER
RECTUM
EJACULATORY DUCT
VAS DEFERENS
PROSTATE GLAND
URETHRA
ANUS
BULBOURETHRAL GLAND
EPIDIDYMIS
SCROTUM
TESTIS

Fig. 4. Male reproductive parts

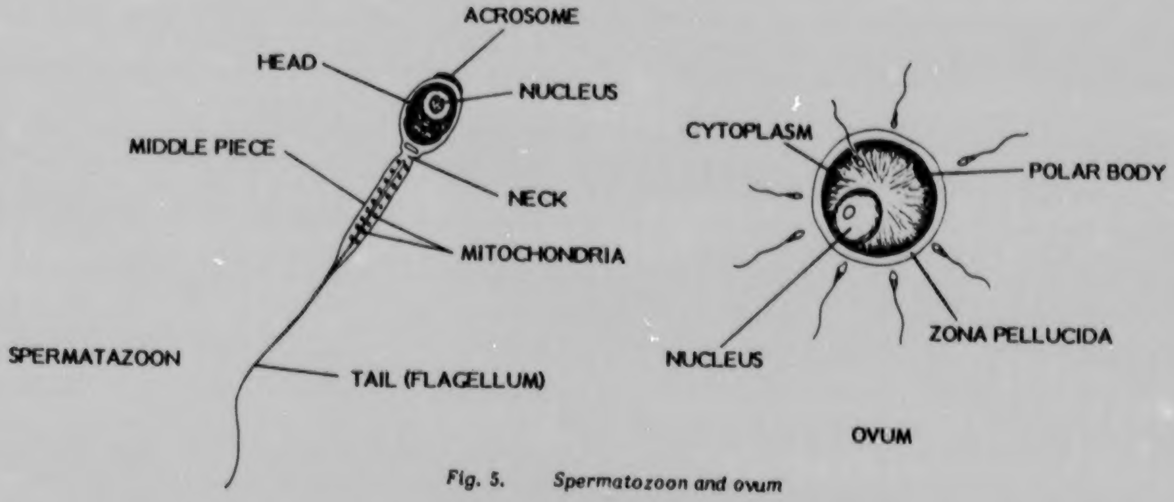
ACROSOME
HEAD
NUCLEUS
MIDDLE PIECE
NECK
MITOCHONDRIA
SPERMATAZOON
TAIL (FLAGELLUM)
CYTOPLASM
POLAR BODY
ZONA PELLUCIDA
NUCLEUS
OVUM

Fig. 5. Spermatozoon and ovum

acrosomal cap), the middle piece (containing mitochondria and the centrosome), and the tail, which is the organ of locomotion (see fig. 5). The two functions of sperm cells are to combine with the ovum in fertilization and to contribute genetic material to the zygote.

Male hormones (androgens), primarily testosterone, are produced in the interstitial cells of the testes.

Sperm cells are conducted from the testes to the urethra by a series of ducts called seminiferous tubules. The first of these is the **epididymis,** which lies along the top and sides of each testis. It is a very small tube about 6 m (20 feet) long, tightly coiled into a small space. It has three functions: (1) to serve as a duct for sperm cells from the testes to the next duct, the vas deferens, (2) to store sperm cells, and (3) to secrete a fraction of the seminal fluid.

The **vas deferens** (ductus deferens) is another spermatic tube. It reaches the epididymis in the scrotum upward through the inguinal canal and into the abdominal cavity. It extends across the top and down the posterior surface of the urinary bladder to join the duct of the seminal vesicle. Together, the ends of these ducts form the ejaculatory duct. The vas deferens secretes a thick fluid that is vital to keeping sperm cells alive (fig. 4).

A common method for male sterilization is a vasectomy. In this procedure an incision is made in the scrotum. The vas deferens is severed, and a small portion of the tube is removed. Each cut end is securely tied. Sperm production is not affected by a vasectomy, but the sperm cells can no longer pass through the vas deferens to the urethra.

The vas deferens connects to the ejaculatory ducts, a pair of short tubes formed by the union of the vas deferens and the ducts of the seminal vesicles. The ejaculatory ducts extend through the prostate gland to the urethra.

The seminal vesicles are pouches or sacs about 2 inches long that are found behind and at the base of the urinary bladder. These vesicles produce a semen component, which is viscous and alkaline. It contains fructose, a sugar that provides energy for the sperm cells. The vesicles combine with the vas deferens to form the ejaculatory duct. The secretion of the seminal vesicles also contains prostaglandins (tissue hormones). Their function is not well understood.

The prostate gland lies just below the urinary bladder and surrounds the urethra. The prostate gland secretes the largest portion of seminal fluid, which is alkaline. Sperm motility seems to be greatest in a neutral or slightly alkaline solution. If the prostate gland enlarges or swells, it may constrict the ureter and interfere with the urinary flow. Sometimes the gland, or a portion of it, is removed to solve this problem.

Cowper's glands (bulbourethral glands) are a pair of small, pea-shaped glands found just below the prostate. They secrete alkaline fluid, a component of semen that empties into the urethra.

The penis and the scrotum are the external male reproductive organs. The penis contains the urethra. Contractions of the epididymis, vas deferens, and the ejaculatory duct force semen into the urethra. The penis is the organ by which sperm cells are introduced into the female vagina.

Semen or seminal fluid is made up of sperm cells and the secretions of the ducts and glands of the male internal reproductive system. These seminal components provide nourishment for spermatazoa and a liquid medium through which they can move. Also, semen has an alkaline pH needed for optimum locomotion of sperm cells. It neutralizes the acid environment of the male urethra and the female vagina.

Males begin to produce sperm cells at puberty and continue throughout life. Sperm cells are produced at the rate of about 300,000,000 each day. They can survive for about 48 hours within the female reproductive tract. Sperm retained in the male reproductive system remain in the seminiferous tubules for a short time, then degenerate and are absorbed.

The number and mobility of sperm cells produced is a factor in sterility. In general, males who produce fewer than 20,000,000 to 50,000,000 sperm cells per milliliter are sterile. In fertilization, a single sperm cell penetrates and fertilizes a single ovum. Then why are such large numbers of sperm cells required? One theory is that the acrosomal cap of each sperm cell contains the enzyme hyaluronidase. Hyaluronidase liquifies the intercellular material that encases the ovum. A single sperm cell does not contain enough of this enzyme to bring about liquefaction, and the combined hyaluronidase from many sperm cells is needed. We know that many sperm cells approach the egg cell, but as fertilization by one occurs, others are repelled (fig. 5).

The activities of the reproductive system are controlled to a large degree by hormones. At puberty, males begin to secrete testosterone, the principal male sex hormone, as a result of stimulation by the anterior pituitary. Testosterone controls the development of male sex organs and thus the formation of sperm cells. It also regulates the development of male secondary sex characteristics. It stimulates protein anabolism, which causes growth of bones and muscles and the broader shoulders and narrower pelvic girdle characteristic of young males. Testosterone also influences the rate at which bones cease to grow at the joints, and thus helps to determine body height and size. Other male secondary sex characteristics are facial and body hair patterns and voice tone.

Diseases and Disorders

Dysfunction and disease of the reproductive system can cause serious health problems. The following list and descriptions are meant only to identify some of the most common.

abortion—loss of embryo or fetus during the first 20 weeks of pregnancy.

AIDS—acquired immune deficiency syndrome; a venereal disease which, in the United States, occurs most often in homosexual males; cause, cure, and treatment are unknown, but the patient's immune system does not function normally. Survival rate is poor.

cryptorchidism—failure of the testes to descend from the abdominal cavity into the scrotum.

dysmenorrhea—painful menstruation with lower abdominal cramps.

ectopic pregnancy—fertilized ovum is implanted at a site other than the uterine cavity, such as the pelvic cavity or oviduct.

gonorrhea—infectious venereal disease that affects the urogenital tract; caused by the bacterium **Neisseria gonorrhoeae** and characterized by a purulent urethral discharge; most common communicable disease after the common cold and influenza.

genital herpes—venereal disease, incurable, caused by a virus called **herpes simplex II**; characterized by painful blisters on the genitalia. The blisters may appear and reappear, but the virus remains. (The typical lip "cold sore" is caused by **herpes simplex I.**)

inguinal hernia—rupture of the abdominal wall in region where testes descend from the abdomen into the scrotum.

orchitis—inflammation of testes; may be due to trauma, mumps, or other infection.

P.I.D. (pelvic inflammatory disease)—any bacterial infection of the uterus, ovaries, or oviducts.

prostatitis—inflammation of the prostate gland; swelling may cause stricture of the urethra with accompanying urine retention.

puerperal fever—infection of the birth canal after delivery.

salpingitis—inflammation of the oviducts.

sterility—inability to reproduce (inability to form sperm cells or ova).

syphilis—infectious venereal disease characterized by lesions which may involve any organ or tissue; caused by **Treponema pallidum.**

tumor—swelling or enlargement; may occur in any part of the reproductive system; common in breasts. Tumors may be benign or malignant (cancerous).

venereal disease—an infectious disease transmitted primarily by sexual contact.

10

The Endocrine Glands

Objectives: *After completing this unit, you will be able to—*

1. *define terms relating to the endocrine system;*
2. *distinguish between endocrine and exocrine glands;*
3. *name five general functions of hormones;*
4. *name the hormones secreted by the thyroid gland, and give the function of each;*
5. *locate the thyroid gland;*
6. *locate the parathyroid glands;*
7. *name the hormone produced by the parathyroid gland, and give its function;*
8. *describe the activity of glucagon and insulin;*
9. *locate the islands of Langerhans;*
10. *locate the pituitary gland;*
11. *list seven hormones secreted by the anterior pituitary, and give the function of each;*
12. *tell what is meant by the term "tropic" hormone;*
13. *list the hormones secreted by the posterior pituitary, and give their function;*
14. *locate the adrenal glands;*
15. *tell what hormones are produced by the medulla and by the cortex;*
16. *discuss the probable functions of the pineal body;*
17. *explain how the thymus gland differs from other endocrine glands;*
18. *give the function of the thymus gland;*
19. *list four gastrointestinal hormones;*
20. *name the function of androgens and estrogens; and*
21. *tell why prostaglandins are called "tissue hormones."*

New Terms and Definitions

anabolism—metabolic process of cells that results in the building of complex compounds.

diuretic—an agent that increases the secretion of urine.

endocrine—pertaining to ductless glands, the secretion of which empties directly into the blood or lymph.

endocrinology—the study of endocrine glands.

exocrine—pertaining to a ducted gland.

gland—a group of cells that produce a secretion.

hormone—the secretions of the endocrine glands.

lactation—secretion of milk in the mammary glands.

lymphocyte—type of leukocyte formed in the lymph tissue.

melanin—one of a group of pigments responsible for skin and eye color.

puberty—period in life in which persons become capable of reproduction.

resorption—to absorb again; to dissolve and assimilate.

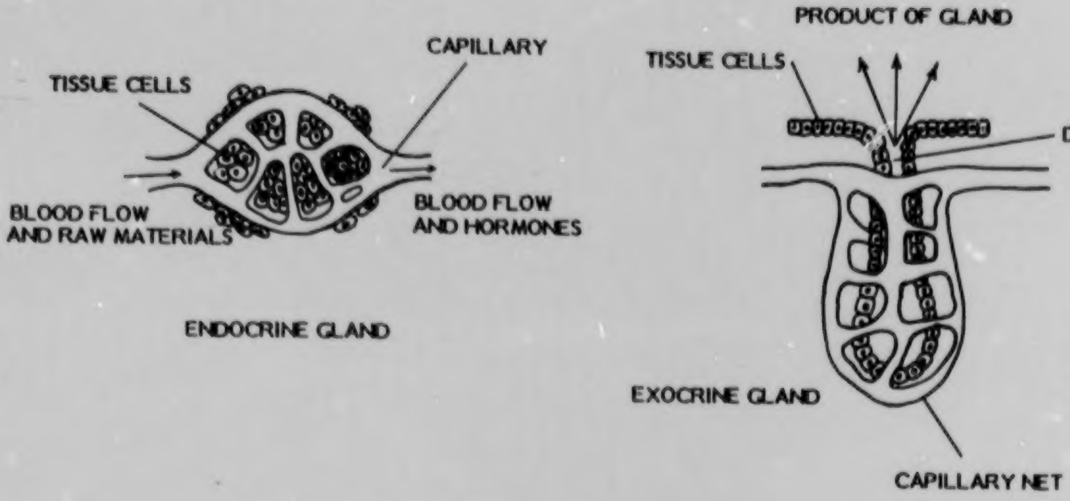
CAPILLARY
TISSUE CELLS
BLOOD FLOW
AND RAW MATERIALS
BLOOD FLOW
AND HORMONES
ENDOCRINE GLAND
PRODUCT OF GLAND
TISSUE CELLS
DUCT
EXOCRINE GLAND
CAPILLARY NET

Fig. 1. Exocrine and endocrine glands

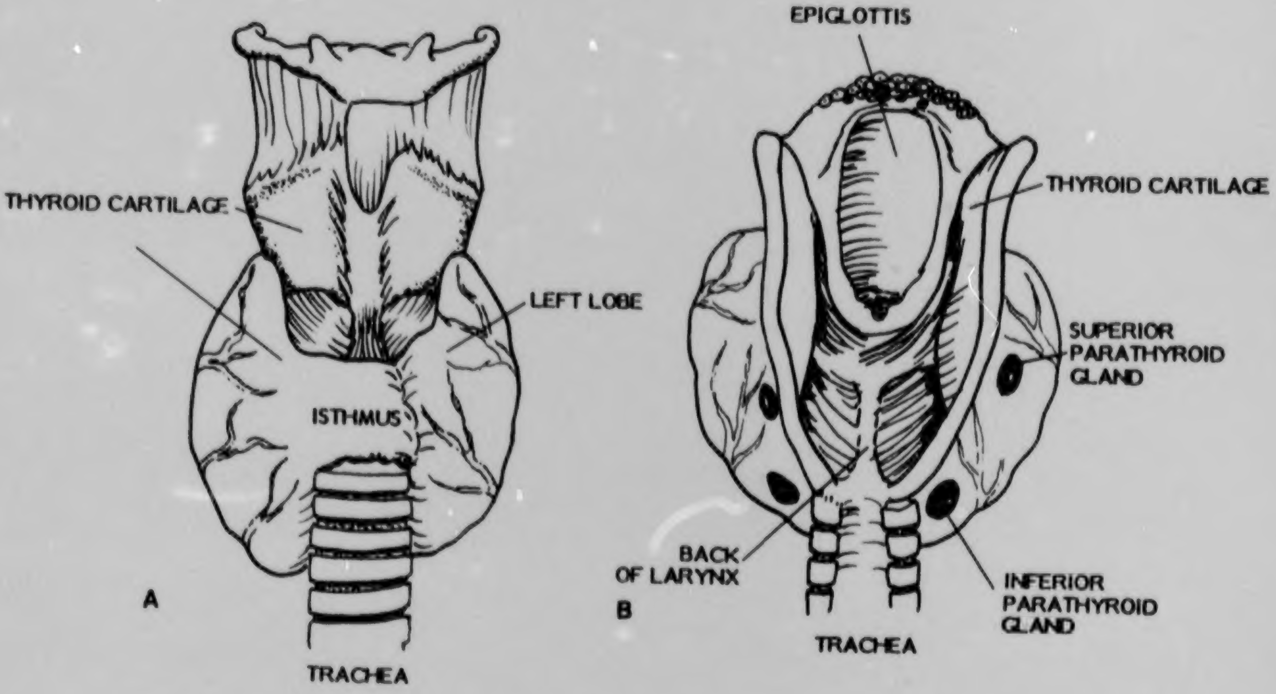
THYROID CARTILAGE
LEFT LOBE
ISTHMUS
A
TRACHEA
EPIGLOTTIS
THYROID CARTILAGE
SUPERIOR
PARATHYROID
GLAND
BACK
OF LARYNX
B
INFERIOR
PARATHYROID
GLAND
TRACHEA

Fig. 2. Thyroid gland: anterior view (A) and posterior view showing parathyroid glands (B)

secondary sex characteristics—sex characteristics that are not directly concerned with reproduction.

vestigial—a small, incompletely developed organ or part; usually has no known function.

All parts of the body are interrelated; none can act totally independently. But the endocrine system and the hormones produced directly affect **every part** of the body, including the various endocrine glands themselves. The endocrine system is made up of endocrine glands placed throughout the body. A **gland** is a group of cells that produce a secretion. In exocrine or ducted glands, the secretion leaves the gland by means of a duct. Endocrine or ductless glands empty directly into the blood or lymph (fig. 1).

The endocrine glands secrete hormones, each of which has a very specific function. However, the **general functions** of hormones are the regulation of metabolism or energy utilization, the regulation of body growth and development, the regulation of reproduction, the regulation of stress response, and the regulation of cell permeability. The excesses or deficiencies of hormones make the difference between a normal and abnormal life, body size and appearance, and even life and death.

The study of the endocrine glands is endocrinology. Endocrinologists isolate hormones and study their functions and the interrelation between them. New information is constantly being provided that helps to explain body activities.

The Thyroid Gland

The location of the endocrine glands seems to have little bearing on their function. Our first example is the **thyroid gland** found in the neck just in front of the trachea and below the larynx (fig. 2). It is shaped like the letter "H" with a right and left lobe connected by an isthmus. It is only about 5 cm long and 3 cm broad, weighs about 30 grams, but it is the largest totally endocrine gland in the body.

The principal function of thyroid hormones is to regulate the metabolic rate, or the rate at which oxidation with the release of energy takes place in the cells. This is vital for normal physical and mental growth and development, as well as constant metabolic needs.

The thyroid gland requires iodine in the diet for hormone production. It takes iodine from the blood in the form of potassium iodide and uses it to synthesize iodine-containing thyroid hormones.

The thyroid gland secretes three hormones, two of which are very similar. The principal hormone is **thyroxine** or tetraiodothyronine **(T_4)**. The second is triiodothyronine **(T_3)**. As these hormones are released into the bloodstream, they combine with a blood protein and move through the body in this combined form. The iodine in protein-bound T_4 and T_3 is called protein-bound iodine **(PBI)**. T_4 and T_3 are released from the protein molecule as they enter the cells from the capillaries.

The normal amount of protein-bound iodine (PBI) is about 4 to 8 mg/100 ml of blood plasma. One way to test a patient's thyroid function is to determine the amount of PBI in the blood. The amount is increased by a hyperactive thyroid gland and decreased by a hypoactive thyroid.

The third hormone is **calcitonin** (thyrocalcitonin), which regulates and maintains a constant calcium level in the blood. The exact manner of its control is not well understood, but it seems to inhibit the resorption of calcium from the bones and in this way lower blood calcium levels.

The control of the hormone production of the thyroid gland is an example of the interrelationship of the endocrine glands. If the levels of T_4 and T_3 fall below normal, or if the metabolic rate lowers, the anterior pituitary is stimulated to produce a hormone called thyroid-stimulating hormone **(TSH)**. This hormone then causes the thyroid gland to produce thyroxine. Thus, the activity of the thyroid gland is dependent on the anterior pituitary.

The determination of PBI is one useful diagnostic procedure to indicate the activity of the thyroid gland. Another method is to determine the patient's basal metabolic rate (BMR). This test measures the amount of oxygen used under basal conditions, which in turn indicates thyroid activity. Sometimes radioactive iodine is used to study the thyroid gland. The patient is given radioactive iodine, which can be detected in the body by means of special instruments. This is not harmful to the patient. Since the thyroid takes in iodine, its size, shape, and activity can be detected.

Disorders of the thyroid result when the amount of hormones produced is too great or too small. Hypothyroidism may be caused by a lack of iodine in the diet or by dysfunction of the thyroid gland itself. This may cause the patient's thyroid gland to enlarge to compensate. This is called simple goiter.

Hypothyroidism decreases the metabolic rate. In infants and children, this deficiency may prevent normal development of the brain and skeleton. Such children may be smaller in size and suffer some mental retardation. This disease is called cretinism. In adults, patients with hypothyroidism may have a decreased heart rate, cold extremities, puffy skin, and water retention. This is called myxedema.

Hyperthyroidism causes an increase in metabolic rate with increased appetite but a loss of weight, and increased respiration, blood pressure, and heart rate. Often the tissue around the eyes swells, causing the eyeballs to protrude (a condition called exophthalmia).

The Parathyroid Glands

There are two pairs of parathyroid glands. They are embedded on the posterior side of the thyroid, arranged symetrically with one pair on each lobe (see fig. 2). The hormone produced by the parathyroids is called **parathormone (PTH)**. Its function is to regulate calcium metabolism and to maintain a constant calcium level.

Calcium ions are necessary in many body functions. Among these are the clotting of blood, the regulation of the permeability of cell membranes, and the maintenance of normal neuromuscular irritability. If the calcium level drops, parathormone stimulates the removal of calcium from other parts of the body. Sometimes calcium is lost from bones by the action of PTH, making them soft and easily bent.

If the parathyroids are unable to produce adequate amounts of PTH, muscle spasms and even convulsions (tetany) and death may occur.

The Islands of Langerhans

The islands of Langerhans are endocrine glands found in the pancreas (see fig. 3). The pancreas lies close to the posterior wall of the abdominal cavity just behind the stomach. It is a unique organ in that it has exocrine glands that secrete digestive enzymes, as well as the endocrine islands of Langerhans that secrete hormones.

The islands of Langerhans secrete two different hormones, glucagon and insulin. These two hormones tend to balance each other to maintain a constant blood glucose level. **Insulin** decreases blood glucose, speeds the movement of glucose from the blood to the cells, and accelerates the conversion of glucose into glycogen, which is then stored. **Glucagon**, on the other hand, controls the rate at which glycogen is converted into glucose, and if the blood sugar level falls it slows the conversion process.

A common disease is diabetes mellitus, which results when the pancreas fails to produce adequate amounts of insulin. Insulin is necessary for the absorption and metabolism of glucose. Persons with diabetes mellitus have an abnormal amount of glucose in the blood, and, if the level becomes high enough, glucose enters the urine. Diabetes is a serious disease. It may cause weight loss, because fats and proteins must be used as a source of energy since glucose cannot be metabolized in large enough quantities for body needs. The blood vessels of the retina may be affected, causing problems with vision, and circulation to the limbs may be impaired.

However, diabetes can be controlled even though the cause cannot be cured. Some patients control diabetes by diet, and some require drugs taken orally to stimulate the pancreas to produce more insulin. However, many people with diabetes must take injections of insulin each day to utilize glucose. Insulin is a protein, and if given orally it is digested and destroyed by enzymes of the digestive system.

Hypoglycemia is the condition in which the blood sugar level is abnormally low. Patients may suffer dizziness, sweating, weakness, and a variety of other symptoms. In severe instances they may lose consciousness. The causes of hypoglycemia are complex and not well understood. In some cases, hypoglycemia may result from disease of the islands of Langerhans with hyperinsulinism; in others, the cause may be excessive glucose absorption, or other conditions that cause hyperinsulinism.

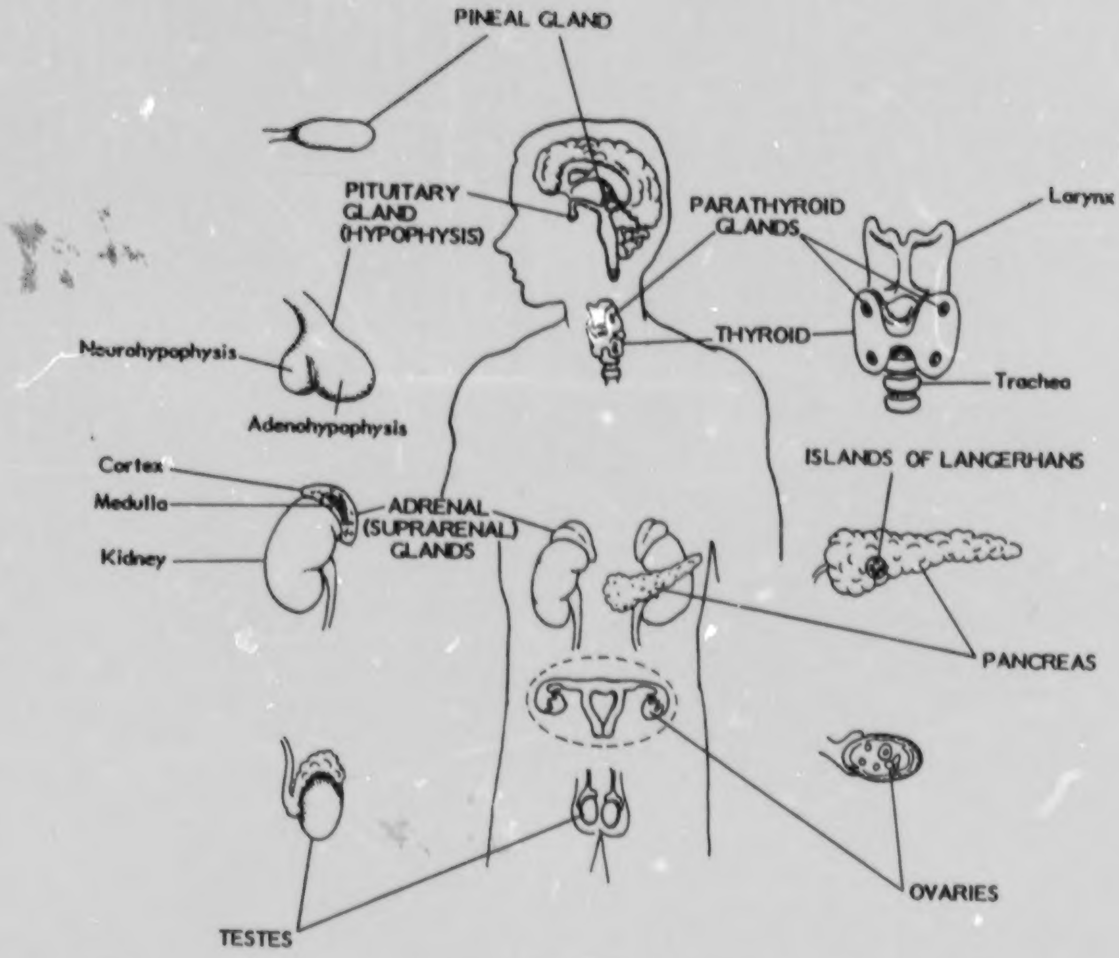
PINEAL GLAND
PITUITARY GLAND (HYPOPHYSIS)
PARATHYROID GLANDS
Larynx
Neurohypophysis
Adenohypophysis
THYROID
Trachea
ISLANDS OF LANGERHANS
Cortex
Medulla
ADRENAL (SUPRARENAL) GLANDS
Kidney
PANCREAS
OVARIES
TESTES

Fig. 3. Endocrine glands

The Pituitary Gland

The pituitary gland is called the **master gland** of the body because it controls or influences the activities of many other endocrine glands. It produces nine separate hormones. It is also called the hypophysis (or hypophysis cerebri). "Hypo" means under, and "physis" means growth. The name hypophysis then means undergrowth and relates to the location of the gland, which is under the brain.

The pituitary (hypophysis) grows under the hypothalamus of the brain and attaches to it by a tiny stalk. It is protected in that it lies in a depression of the sphenoid bone and is covered by the dura mater. It is a very small, round gland measuring only about 1.2 to 1.5 cm in width and weighing about 0.5 gm. It is divided into two lobes, called anterior and posterior, or adenohypophysis and neurohypophysis. The two lobes have totally different functions and are derived from different embryonic tissue.

The adenohypophysis produces seven known hormones (fig. 4). One is **somatotropin** or **growth hormone (GH)**, which regulates skeletal and muscular growth and development. It does not affect other endocrine glands, as many pituitary hormones do. It promotes growth by causing amino acids to be sent to the skeletal cells, thus enhancing cellular growth. An excess of GH in children before the cartilage is replaced by bone causes giantism or abnormally large skeletal size. A deficiency of GH results in dwarfism. If the anterior pituitary produces an excess of somatotropin (GH) in adults, it results in a disease called acromegaly, where only those bones that can continue to grow will increase in size. These include the bones of the hands, feet, and jaw. The soft tissue of these areas also continues to grow, giving the person a bizarre appearance.

As a side note, the function of the endocrine glands in other mammals is similar to that in humans. In some instances, glandular dysfunction is hereditary, and the once abnormal characteristics are transmitted from parent to offspring. In dogs, the face of the pit bull is the result of hereditary acromegaly, the Great Dane is a giant, and the dachshund and Pekinese are dwarfs.

A second effect of GH is to decrease the catabolism of glucose. Thus, an excess may cause an increase in glucose in the blood and even diabetes.

Prolactin (lactogenic hormone) **(PR)** is a second hormone produced by the adenohypophysis. It stimulates the production of milk in the mammary glands after the delivery of a baby, and the general development of the breasts during pregnancy. PR also, in conjunction with a second hormone, luteinizing hormone, helps to maintain the corpus luteum in the premenstrual phase of each menstrual cycle. (The corpus luteum is discussed in the unit on reproduction, Unit 9.)

Thyrotropin (thyroid-stimulating hormone) **(TSH)** is also produced by the anterior pituitary. Its function is to stimulate the growth of the thyroid gland and the production and secretion of thyroid hormones.

A fourth hormone secreted by the anterior pituitary is **ACTH (adrenocorticotropin).** It controls the normal growth and development of the adrenal cortex and the synthesis and secretion of cortisol (hydrocortisone) and other glucocorticoids.

The **follicle-stimulating hormone (FSH)** stimulates the development of egg cells in the ovaries to ovulation and the production of estrogen. In males, FSH stimulates the testes to produce sperm cells.

Luteinizing hormones also stimulate the ovaries and testes. In females, the hormone is called luteinizing hormone **(LH)**. The corresponding hormone in males is called interstitial-cell stimulating hormone **(ICSH)**. (Interstitial cells are groups of cells in the testes.) LH stimulates ovulation, the production of corpus luteum, and prepares the uterus for implantation of a fertilized egg. It also causes the secretion of progesterone, which readies the mammary glands for the production of milk. ICSH stimulates the testes to develop and secretes testosterone, a male sex hormone.

Four of the seven hormones secreted by the anterior pituitary are called **tropic** hormones. This means that their hormones stimulate other endocrine glands in growth and development and in the secretion of hormones. They are very specific in their action:

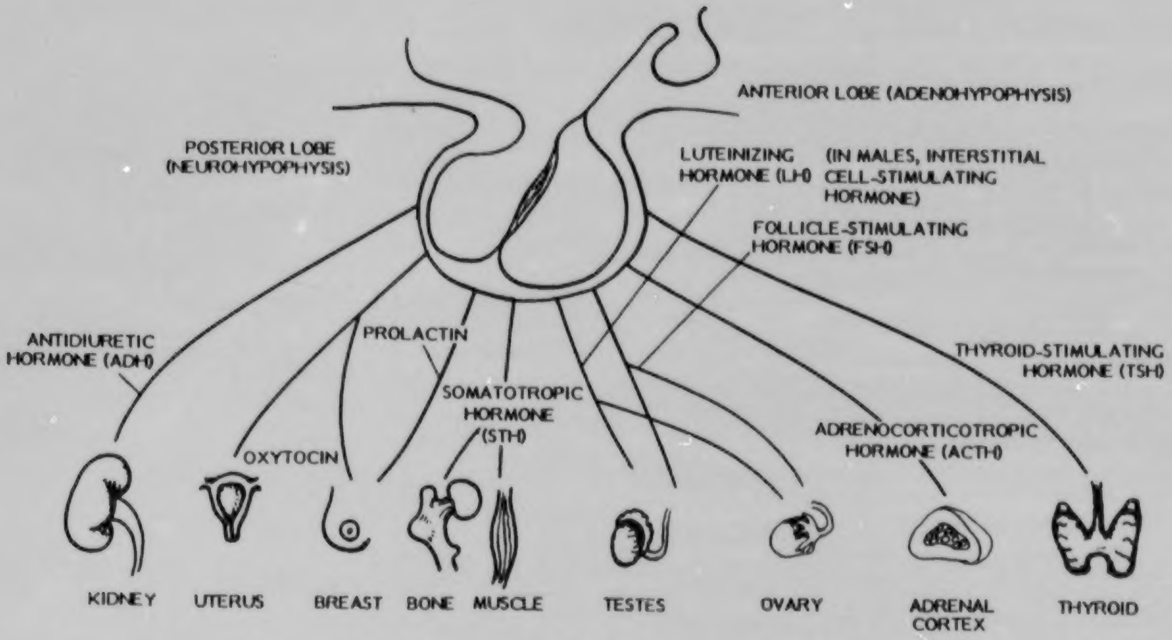
ANTERIOR LOBE (ADENOHYPOPHYSIS)
POSTERIOR LOBE (NEUROHYPOPHYSIS)
LUTEINIZING HORMONE (LH)
(IN MALES, INTERSTITIAL CELL-STIMULATING HORMONE)
FOLLICLE-STIMULATING HORMONE (FSH)
ANTIDIURETIC HORMONE (ADH)
PROLACTIN
THYROID-STIMULATING HORMONE (TSH)
SOMATOTROPIC HORMONE (STH)
ADRENOCORTICOTROPIC HORMONE (ACTH)
OXYTOCIN
KIDNEY
UTERUS
BREAST
BONE
MUSCLE
TESTES
OVARY
ADRENAL CORTEX
THYROID

Fig. 4. Structures influenced by various pituitary hormones

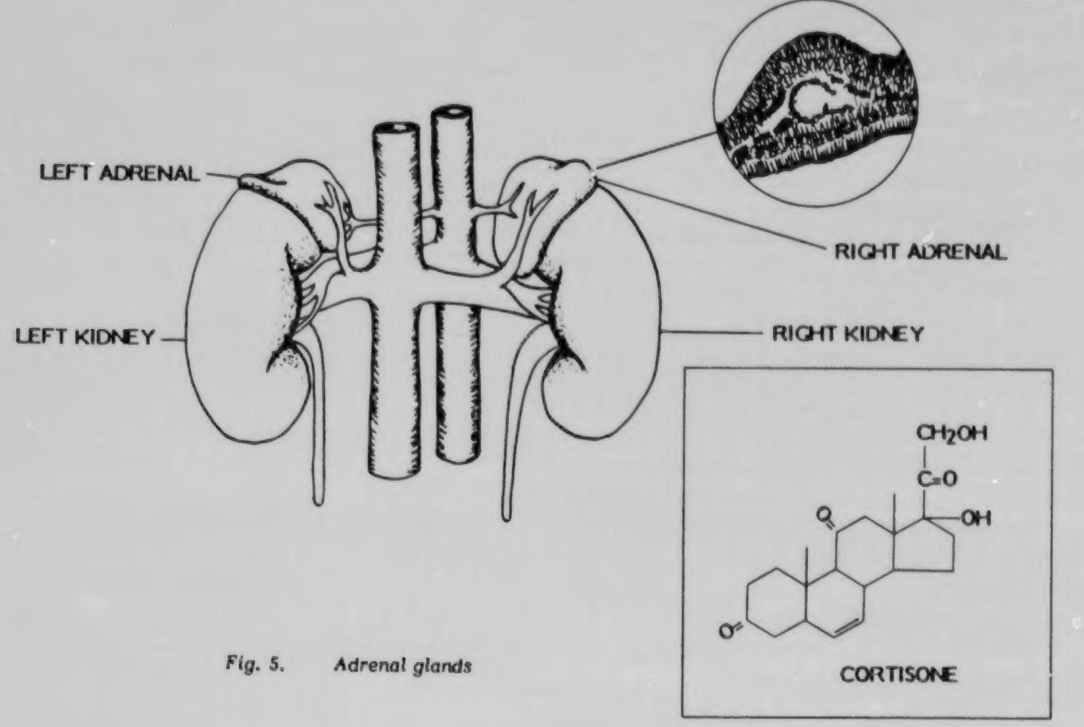
LEFT ADRENAL
RIGHT ADRENAL
LEFT KIDNEY
RIGHT KIDNEY
CH2OH
C=O
O
OH
O
CORTISONE

Fig. 5. Adrenal glands

- Thyrotropin (TSH) stimulates the thyroid gland.
- Adrenocorticotropin (ACTH) stimulates the adrenal gland.
- Follicle-stimulating hormone (FSH) and luteinizing hormones (LH and ICSH) stimulate the male and female reproductive organs.

The function of the tropic hormones FSH, LH, and ICSH should be studied in conjunction with the reproductive system. This will make it easier to understand the activities described. Only insignificant amounts of gonadotropins or sex hormones are produced until just prior to puberty. Then, because of stimulation of these hormones, high levels of sex hormones are produced and liberated, bringing about the initiation of menstruation and other marked changes of puberty.

Another hormone produced by the anterior pituitary that does not affect other endocrine glands is the melanocyte-stimulating hormone **(MSH)**. This hormone brings about an increase in the production and scattering of melanin granules in the skin. Melanin is the pigment that gives color to skin. The more melanin present, the darker the skin color.

The posterior pituitary (neurohypophysis) produces two hormones. One is **vasopressin** or antidiuretic hormone **(ADH)**. It decreases water loss from the body. Since a diuretic stimulates the secretion of urine, an antidiuretic would prevent the formation of large quantities of urine. ADH causes the kidneys to remove water from urine and return it to the bloodstream.

Various factors affect the pituitary. For example, ethyl alcohol causes the pituitary to produce less ADH, which in turn causes an increase in urinary output.

A disease called **diabetes insipidus** results when vasopressin is diminished. The patient produces large amounts of urine. This disease is not related to **diabetes mellitus** in which the islands of Langerhans fail to produce adequate insulin. Diabetes insipidus can be controlled by the administration of vasopressin.

A second hormone produced by the posterior pituitary is **oxytocin.** This hormone stimulates the contraction of the smooth muscles of the uterus in childbearing. It also causes milk to be ejected into the mammary glands.

The Adrenal Glands

The adrenal glands (also called **suprarenal**) are found just above each kidney (fig. 5). They are only about 5 cm long, 3 cm wide, and weigh about 4 grams each. They are yellowish in color, but like all endocrine glands, they have an excellent blood supply. The adrenals have three distinct parts, the cortex or outer portion, the medulla which is the middle portion, and an inner zone.

The cortex secretes hormones called **glucocorticoids.** Three glucocorticoids are hydrocortisone, corticosterone, and cortisone. **Hydrocortisone** occurs in the greatest quantity. The overall function of the glucocorticoids is to maintain normal metabolism and to prepare the body to cope with stress. They regulate the carbohydrate reserve, and, in stress, cause amino acids to be converted to sugar instead of into protein to provide the body with a great supply of glucose. This conversion provides energy to cope with emotional or physical stress such as infection, fright, or temperature extremes. The secretion of hydrocortisone is stimulated by adrenocorticotropin (ACTH) from the anterior lobe of the pituitary gland.

The cortex of the adrenals also secretes hormones called **mineralocorticoids.** The main one of these is **aldosterone.** Its function is to regulate electrolyte and water balance in the tissues by controlling the resorption of sodium and water. At the same time, aldosterone controls the elimination of potassium ions by the kidneys.

The adrenal cortex also produces a third type of hormone, the gonadocorticoids. These are male sex hormones (androgens) and female sex hormones (estrogens). They are normally secreted in insignificant amounts by the adrenal glands in adults.

The medulla of the adrenal glands secretes epinephrine (adrenaline) and norepinephrine. About 80 percent of the secretion is epinephrine. These hormones also assist the body to cope with stress. **Epinephrine** causes the heart rate to increase, constricts blood vessels, and thus raises blood pressure. It stimulates cell metabolism, slows digestion, causes the rate of respiration to increase, and in general helps the body to withstand stress. **Norepinephrine** specifically causes the constriction of blood vessels, which increases blood pressure. Thus, if a person is suddenly frightened, threatened, or in any way stressed, epinephrine and norepinephrine prepare the body for action. The digestion of food can wait, but the brain and muscles need extra energy. The extra oxygen from rapid respiration, the extra blood supply from increased blood pressure and heart rate, and the higher rate of cell metabolism prepares the body for emergency action and heightened brain activity. The body adapts well to short-term stress, but it is easy to see why long-term stress is harmful.

The Pineal Body

The pineal body gets its name from its shape, which resembles a pine cone. It is located in the roof of the third ventricle of the brain behind the midbrain. Because of its location, early anatomists called it the "seat of the soul." Even now the function of the pineal body is not well understood.

The pineal body is present in children until about the age of seven. Then it begins to atrophy, and glandular tissue is replaced with fibrous tissue.

It does secrete hormones. One of these is melatonin. In lower animals, it causes the skin to lose color and become pale. This function in humans has not been demonstrated. Melatonin seems also to affect the secretion of ovarian hormones, and perhaps affect the menstrual cycle.

The pineal body is thought to produce another hormone, adrenoglomerulotropin, which stimulates the adrenal gland to produce aldosterone. Additional study of the pineal and its hormones will surely provide more specific information.

The Thymus Gland

The thymus gland is located in the chest in front of the aorta but behind the sternum (fig. 6). It is in two lobes and appears pinkish in color. It is unusual in that it is conspicuous in infants and continues to grow until puberty or a little later. Then it gradually atrophies and is replaced by fat and connective tissue. Some authorities say the thymus enlarges again in old age.

The thymus gland secretes the hormone **thymosin,** which is critical in the development of the immune system. Until fairly recently, the function of the thymus was not understood, and it was generally thought to be useless or even vestigial tissue. Now we know that it is important in the development of lymphocytes.

As lymphocytes are released after development, about half of them go to the thymus gland before they assume their place in lymphoid tissue. These lymphocytes are called **"T" cells.** During their stay in the thymus gland, they are, in a manner not well understood, modified to destroy antigens of invading bacteria. With this capability they are more effective in destroying bacteria. They are particularly effective against some bacteria, such as those that cause tuberculosis and brucellosis, and some fungi and viruses.

Because injections of thymosin stimulate the production of "T" cells, perhaps the hormone may be used to activate the immune system of patients whose immunity is impaired.

The Gastrointestinal Glands

The gastrointestinal mucosa contains some endocrine glands that produce hormones that influence the digestive process. One of these is **gastrin,** which is secreted from the gastric mucosa. Its function is to speed up the secretion of pepsin and hydrochloric acid by the digestive gland of the stomach.

A second hormone is **enterogastrone** which is released by the intestinal mucosa. It reacts when fats are in the intestine by lessening gastric secretion and decreasing gastric motility.

Secretin is another gastrointestinal hormone produced in the intestinal mucosa. Its function seems to be to neutralize chyme and stimulate the production of bile and pancreatic juice.

A fourth gastrointestinal hormone is **cholescystokinin.** It also enhances the activity of the pancreas and the liver.

All of these hormones augment the activity of the gastrointestinal exocrine glands.

The Gonads

The ovaries and testes produce hormones as well as sex cells. Male sex hormones are called androgens. The best-known androgens are testosterone and androsterone. These hormones stimulate the development

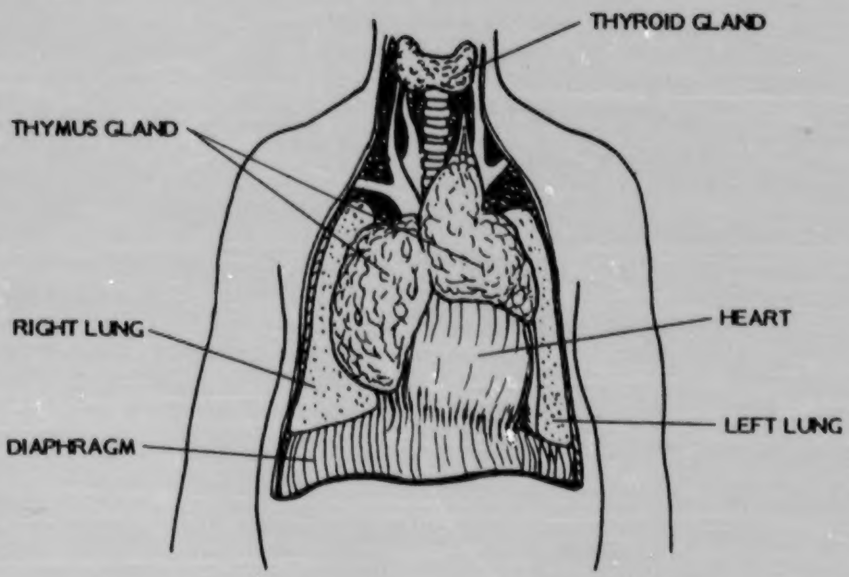
THYROID GLAND
THYMUS GLAND
RIGHT LUNG
HEART
LEFT LUNG
DIAPHRAGM

Fig. 6. Thymus gland in young child

of male reproductive organs and of male secondary sex characteristics, such as the deeper voice, body and facial hair, skeletal changes in the hips and shoulders, and the development of muscles.

The ovaries in females produce **estrogens** or female sex hormones. These bring about the initiation of the menstrual cycle and the rhythmic changes in the female reproductive system. Female sex hormones also help to maintain pregnancy and to prepare the mammary glands for lactation. Estrogens stimulate the development of female secondary sex characteristics, such as skeletal changes to accommodate pregnancy and breast development. The activities of the sex hormones are discussed in greater detail in the unit on reproduction (Unit 9).

Secondary sex characteristics are sex characteristics that are not directly concerned with reproduction, but are definitive for each sex. They develop most rapidly during puberty, the period in life in which persons become capable of reproduction.

Prostaglandins are a group of lipids (fatty acid derivatives) produced in almost all mammalian cells. They are called "tissue hormones" because they are secreted into the blood, are very active, and are thought to regulate hormone activity at the cellular or tissue level. They are produced in minute amounts, so their circulating level is very low. Also, since they are quickly decomposed by catalytic enzymes, their activity is limited to a small area of nearby cells.

Prostaglandins are thought to affect the cardiovascular system and regulate blood pressure. They also affect the gastrointestinal system in regulating the production of stomach secretions and the muscular contractions of the gastrointestinal tract. They stimulate uterine contractions and induce labor at the termination of pregnancy.

Prostaglandins are of great interest because they seem to affect overall endocrine activity and have great potential for therapeutic use. Much more investigation is needed to understand their role better.

All hormones function to regulate body activities (fig. 7). Many of the activities are interdependent, and one hormone requires the action of another. Their overall size and body weight is very small, the volume of endocrine secretion is small, but their activity is of immeasurable importance.

ENDOCRINE GLANDS, HORMONES, AND THEIR FUNCTIONS

Gland	Location	Hormone	Primary Function
Thyroid	Tracheo-laryngeal region	1. Thyroxine or Tetraiodothyronine (T_4) 2. Triiodothyronine (T_3)	Regulates metabolism
		3. Calcitonin	Regulates calcium balance
Parathyroids	Posterior surface of the thyroid	Parathormone (PTH)	Regulates calcium metabolism and maintains a constant calcium level
Islands of Langerhans	Pancreas	1. Insulin	Regulates rate of glucose metabolism. Regulates concentration of glucose in the blood. Converts glucose to glycogen
		2. Glucagon	Maintains glucose concentration by causing liver to convert glycogen to glucose
Pituitary (Hypophysis)	Base of the brain		
Anterior Pituitary (Adenohypophysis)		1. Growth hormone (GH) or Somatotropin (STH)	Regulates skeletal and muscular growth
		2. Prolactin (PR) (Lactogenic hormone)	Stimulates milk secretion and breast development during and after pregnancy Helps maintain corpus luteum in premenstrual phase of cycle (with luteinizing hormone)
		3. Thyroid-stimulating hormone (TSH)	Stimulates the production of thyroxine and triiodothyronine
		4. Adrenocorticotropic hormone (ACTH)	Controls the normal growth and development of the adrenal cortex Stimulates the production of cortex hormones (hydrocortisone and glucocorticoids)
		5. Follicle-stimulating hormone (FSH)	Stimulates development of egg cells and production of estrogens in females
		6a. Luteinizing hormone (LH) (in females)	Stimulates ovulation, prepares uterus for implantation of fertilized egg Causes secretion of progesterone, which readies mammary glands for milk production
		6b. Interstitial-cell stimulating hormone (ICSH) (in males)	Stimulates testes to develop and secrete testosterone
		7. Melanocyte-stimulating hormone (MSH)	Regulates deposition of melanin in the skin
Posterior pituitary (Neurohypophysis)		1. Vasopressin or Antidiuretic hormone (ADH)	Decreases water loss
		2. Oxytocin	Promotes generalized contraction of smooth muscles, particularly the uterus in late pregnancy Causes milk to be ejected into mammary glands
Adrenals	Above each kidney		
Cortex		1. Mineralocorticoids, mainly aldosterone	Controls water and electrolyte balance, particularly sodium and potassium
		2. Glucocorticoids (hydrocortisone, corticosterone, and cortisone)	Maintains normal metabolism Helps body to resist stress
Medulla		1. Epinephrine (Adrenaline)	Helps body to cope with emergency situations
		2. Norepinephrine	Constricts blood vessels to raise blood pressure in stress
Pineal*	Brain	Melatonin (produced in some animals)	Affects color in some animals
Thymus	In chest behind sternum	Thymosin	Is critical in development of immune system

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Gland	Location	Hormone	Primary Function
Gastrointestinal	Gastrointestinal mucosa	1. Gastrin	Speeds up secretion of pepsin and HCl by digestive glands of stomach
		2. Enterogastrone	Lessens gastric activity when fats are in the intestine
		3. Secretin	Neutralizes chyme and stimulates the production of bile and pancreatic juice
		4. Cholecystokinin	Enhances activity of pancreas and liver
Gonads			
Testes in males	Scrotum	1. Testosterone 2. Androsterone	These two hormones together stimulate development of male reproductive organs and male secondary sex characteristics
Ovaries in females	Abdominal cavity	Estrogens	Initiates menstrual cycle and rhythmic changes in female reproductive cycle
			Helps to maintain pregnancy, and prepares for lactation
			Stimulates development of female secondary sex characteristics

---

* The pineal body is also thought to produce adrenoglomerulotropin, which stimulates the adrenal gland to produce aldosterone.

Fig. 7. Endocrine glands, hormones, and their functions

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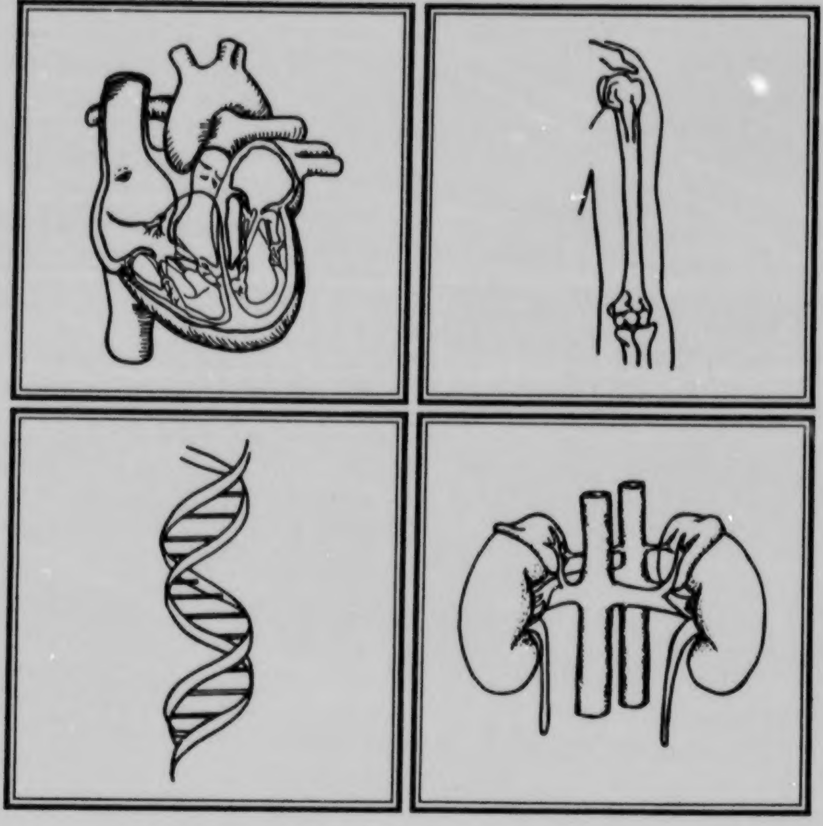
Applied Anatomy and Physiology

INSTRUCTOR'S GUIDE



Applied Anatomy and Physiology

Instructor's Guide

By

Catherine Williams

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COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

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If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964: EXECUTIVE ORDERS 11246 and 11375; TITLE IX 1973 EDUCATION AMENDMENTS: REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

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Foreword

This publication, Applied Anatomy and Physiology, is designed for health occupations students. It is to be used along with other curricular materials, such as that which contains the essential elements for the various courses, and for the specific occupations. It contains basic concepts and specific information needed for understanding anatomy and physiology, with emphasis on those areas of particular interest to health occupations students.

The format of this publication lends itself to use in the classroom, but it may also be used for individualized study. Two publications are offered—a student's manual and an instructor's guide. The student's manual contains objectives and information. The instructor's guide provides a competencies progress chart, teaching objectives, review questions with answers, unit tests and answers, and suggested activities with answers. The suggested activities in particular should be used at the discretion of the instructor, as a group activity or as an individual activity.

Every effort has been made to produce a publication that addresses the unique needs of our current student population. Students with limited English proficiency (LEP) as well as handicapped, educationally disadvantaged, and nontraditional students may require modification of the material in this publication. The professional staff of EIMC will gladly work with any instructor having these students to show how the instructional material can be adapted for specific individualized instruction. Consult local, state, and federal agencies that offer assistance and guidance and that can provide sound recommendations for productive classroom management.

Kathryn R. Allen, Ph.D.
Director, Extension Instruction
and Materials Center

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Notes for the Instructor

This publication is an introduction to anatomy and physiology. Students continuing their education in the health field will need to study this subject in greater depth and with detailed laboratory procedures. Students may choose advanced courses in anatomy and physiology that apply specifically to the health occupations area they have elected to pursue.

It is suggested that this publication could be used as a vehicle in articulating the various courses in which health occupations students are enrolled. The goal of articulation is the whole education of the student where all classes are woven together to produce an educational composite, rather than having isolated areas of specialized learning.

Although the information presented relates specifically to anatomy and physiology, the suggested activities are designed to provide a variety of learning devices that lend themselves to articulation. Vocabulary practice, word puzzles, and games are all designed to help the student develop a working knowledge of technical terms and to improve her/his understanding. The same terms may be used in other contexts, and the methods used may be appropriate for other vocabulary needs.

The charts, models, and diagrams are useful in helping the student to identify and locate specific anatomical parts. These materials may also be used in other courses, so that only review is needed. The time saved by avoiding repetition can be spent in other areas.

The review questions help the student to identify the important information presented. If used for class discussion, they serve as an organizational tool. The experiments and demonstrations provide an opportunity for students to glean information for themselves. Some of these may require materials and equipment from other laboratory sciences, or they may be done in other science classes. The suggested research paper or project should be related to the student's work or specific interest. Many students will choose topics of sociological concern, such as tissue transplants, conception control, or environmental protection. Such research takes on added significance when the correlation between work experience and school is clear. The rules of composition, grammar, and research are more readily learned when students can see a reason for these techniques.

The study of diseases is a cursory introduction to common diseases and is an area that many health occupations students find very interesting. Often students will wish to discuss other diseases in class.

The tests are designed to indicate the student's progress. Most instructors will wish to modify them or use them as a guide in preparing their own tests that better reflect the emphasis on areas covered in the individual classroom. Some students will perform better with oral testing.

Every effort has been made in preparing this material to avoid sex bias or discrimination. It may be used at different academic levels; and for nonreaders, there should be less emphasis on verbal detail and more on manipulative skills.

In preparing this publication, the purpose was to present current, accurate information about human anatomy and physiology, and to prepare activities that would demonstrate articulation between the health occupations program and traditional academic subjects as well as enhance learning of the information.

Unit 1

The Organization and General Plan of the Body

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms related to the organization and general plan of the body;
2. identify studies related to anatomy and physiology;
3. list and describe the levels of structural organization of the body;
4. define **anabolism** and **catabolism**;
5. name, locate, and give the function of cell parts;
6. describe special structures that modify cells for a specific role;
7. name four types of tissue, and give the general function of each;
8. give examples of organs;
9. name the nine major systems in the human body;
10. define directional terms used to locate body parts;
11. name the four quadrants of the abdominopelvic cavity;
12. name the nine regions of the abdominopelvic cavity when the area is divided;
13. locate body cavities, and tell what organs are contained in each; and
14. name and locate three body planes.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification of the Parts of the Cell"

Study of the diagram and/or model of the cell and identification of the parts will enhance the descriptions given in the text. Study of actual cells with the microscope will provide a more accurate concept of cell size and structure.

Suggested Activity #3: "Summary of Cell Activities"

This activity is designed to reinforce students' comprehension of the activities of the various parts of the cell.

Suggested Activity #4: "Identification of the Abdominal Regions"

By making sketches of the abdominal regions, students will develop a better concept of the various areas and their relation one to the other. They will also learn the correct terminology for the different areas.

Suggested Activity #5: "Identification of Body Cavities"

The use of charts, models, and diagrams makes it easier for students to develop a concept of the location and relation one to the other of the various body cavities.

Suggested Activity #6: "Use of Directional Terms to Locate Body Parts"

Health occupations students must learn technical terms in order to communicate with their co-workers and supervisors. This activity provides practice in the use of directional terms, using a chart of terms and a diagram of the body to demonstrate the terms.

Unit 1

Review Questions

1. Define **anatomy** and **physiology.**
2. What are five other branches of science that relate to anatomy and physiology?
3. Name the protoplasm of which cells are made.
4. What is the difference between **anabolism** and **catabolism**?
5. What does it mean to say that the plasma membrane is "selectively permeable"?
6. What are four functions of the plasma membrane?
7. Where is the cytoplasm in the cell located?
8. What activities take place in the cytoplasm?
9. What are **organelles**?
10. What is the **endoplasmic reticulum**?
11. What are three functions of the endoplasmic reticulum?
12. What is the function of the ribosomes?
13. What is the function of the Golgi apparatus?
14. Where are the cristae located?
15. What is the function of the mitochondria?
16. Describe lysosomes.
17. What is the function of lysosomes?
18. What becomes of its components when a cell dies?
19. What is unique about the position of centrosomes?
20. What is the function of centrosomes?
21. Name two general functions of the cell nucleus.
22. Of what are the nuclei composed?
23. Where in the cell is DNA found?
24. Where are red blood cells produced?
25. Name three types of cell modifications.
26. What is **phagocytosis**?
27. What is a tissue?
28. Name four kinds of tissue.
29. What is the function of epithelial tissue?
30. What is the function of connective tissue?
31. What is the function of muscle tissue?
32. Name three kinds of muscle tissue.
33. What is the function of nervous tissue?
34. What is an **organ**?
35. Name nine major systems of the body.
36. What is an **organism**?
37. What term is used for each of the following body directions?
    a. front, in front of
    b. toward the midline
    c. away from the point of origin
    d. pertaining to organs inside the body cavity, particularly the abdominal cavity
38. Where are the lines drawn for dividing the abdominopelvic cavity into quadrants?
39. Starting with the upper right division as a page is read, name the nine regions of the abdominopelvic area.
40. In which body cavity are the following structures found? (a) brain, (b) spinal cord, (c) lung, (d) liver, (e) urinary bladder
41. Describe the anatomic position.
42. Name three body planes, and identify each.

ANSWERS TO REVIEW QUESTIONS

1. **Anatomy** is the study of the structure of the body. **Physiology** is the study of the function of the body.
2. Almost any other science. Those listed in the text are:
   - biology
   - chemistry
   - physics
   - cytology
   - histology
   - kinesiology
   - osteology
   - endocrinology
   - pathology
   - hematology
   - genetics
   - nutrition
3. cytoplasm
4. The building processes of metabolism are called **anabolism.** The breaking down of complex compounds, usually with the release of energy, is **catabolism.**
5. that needed materials may enter the cell by osmosis, but harmful molecules are excluded
6. It determines the entry of molecules by osmosis, identifies cells of each individual, sends and receives messages, and in white blood cells acts as an antibody.
7. It is the part of the cell between the plasma membrane and the nucleus.
8. anabolism (the building of complex compounds from raw materials) and catabolism (the breaking down of complex compounds with the release of energy)
9. living particles contained in the cytoplasm of the cell
10. an organelle that is a system of interconnected channels that extend throughout the cytoplasm
11. (1) to transport materials within the cell
    (2) to increase the surface area where chemical reactions (protein synthesis) can take place
    (3) to provide storage for molecules synthesized
12. protein synthesis
13. synthesis of large carbohydrate molecules and combination of these with protein molecules from the endoplasmic reticulum to form glycoproteins
14. The cristae are the inward folds of the inner membrane of the mitochondria.
15. the release of energy
16. bubblelike structures enclosed in a membrane
17. to digest and destroy particles or molecules that have invaded the cell by the action of digestive enzymes
18. They are digested by lysosomes.
19. They lie at right angles to each other.
20. They are involved with cell division or mitosis
21. It controls and regulates the metabolic activities and reproduction of the cell.
22. RNA (ribonucleic acid)
23. in the chromatin granules of the nucleus
24. in the bones
25. (1) flagella
    (2) cilia
    (3) microvilli
26. the process by which a cell membrane flows around a foreign object or bacteria and engulfs, digests, and destroys it
27. a group of like cells
28. (1) epithelial
    (2) connective
    (3) muscle
    (4) nerve
29. protection, absorption, and secretion

30. to provide support, form blood cells, and connect other tissues
31. to contract
32. (1) skeletal
    (2) visceral (smooth)
    (3) cardiac
33. to transmit information and nerve impulses throughout the body and control body activity
34. various tissues that together perform a function
35. (1) digestive, (2) circulatory, (3) respiratory, (4) nervous, (5) endocrine, (6) reproductive, (7) urinary, (8) skeletal, and (9) muscular
36. a whole, living thing
37. a. anterior c. distal
    b. medial d. visceral
38. horizontally and vertically through the umbilicus
39. (1) right hypochondriac, (2) epigastric, (3) left hypochondriac, (4) right lumbar, (5) umbilical, (6) left lumbar, (7) right inguinal, (8) hypogastric, and (9) left inguinal
40. (a) cranial, (b) spinal, (c) pleurae, (d) abdominal, (e) pelvic
41. The body is erect and facing the observer. The arms are at the sides with the palms turned forward.
42. (1) The **median** (midsagittal) divides the body into equal right and left sides by a vertical line.
    (2) The **frontal** (coronal) divides the body evenly into anterior and posterior segments by a vertical line.
    (3) The **transverse** divides the body into superior and inferior segments by a horizontal line.

Suggested Activity #1: Practice with New Terms

UNIT 1

Match the following terms with the definitions using letter answers.

____ 1. the membranes that cover the lungs and line the chest wall

____ 2. pertaining to the skull or cranium

____ 3. the portion of the abdomen beneath the lower ribs on each side of the epigastrium

____ 4. region of the groin

____ 5. small sac or bladder containing fluid; a blister

____ 6. type of cell division

____ 7. allows the passage of substances, as through a membrane

____ 8. standing erect with arms at the sides and palms forward

____ 9. the engulfing and destruction of foreign particles of bacteria by some cells

____ 10. region over the pit of the stomach

____ 11. hairlike processes extending from the body of a cell

____ 12. the sum of the chemical processes of the body

____ 13. region of the back between the ribs and the pelvic girdle

____ 14. microscopic projections from cells to increase surface area; found in the lining of the small intestine

____ 15. pertaining to the production and development of blood cells

____ 16. living particles contained in the cytoplasm of the cell (little organs)

____ 17. the absorption of liquids by some cells

____ 18. the navel

a. anatomic position
b. cilia
c. cranial
d. cristae
e. epigastrium
f. flagellum
g. genetic
h. hemopoietic
i. hypochondrium
j. inguinal
k. lumbar
l. metabolism
m. microvilli
n. mitosis
o. organelle
p. permeable
q. phagocytosis
r. pinocytosis
s. pleurae
t. umbilicus
u. vesicle

_____ 19. single whiplike extension from the main body of some cells; used in locomotion

_____ 20. partitions formed by the folds of the inner membrane of the mitochondria

_____ 21. pertaining to heredity

Suggested Activity #2: Identification of Parts of the Cell

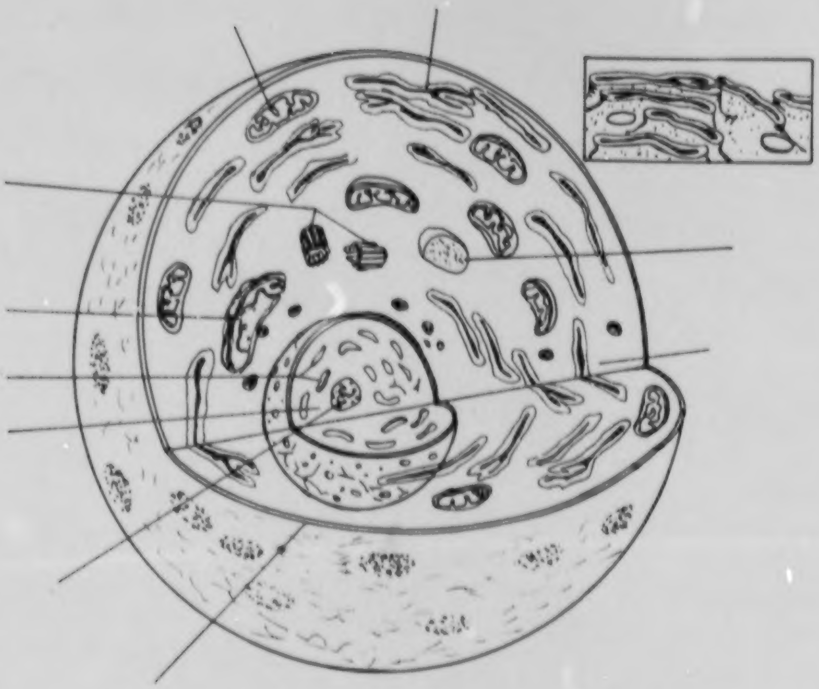
Objective: To identify the parts of the cell

Materials: Diagram of the cell (fig. 3)
Model of cell, if available
Demonstration of prepared slide of stained cells under microscope

Procedure:

1. Review the parts of the cell from figure 3.
2. Identify the parts of the cell from the model.
3. Study the prepared slides under the microscope to identify parts. (Remember, you will not be able to see detailed parts at this magnification.)

Results: Write the parts of the cell on the unlabeled figure without using references.



Suggested Activity #3: Summary of Cell Activities

Directions: Match the descriptions with the cell parts listed here:

centrosomes
chromatin
cristae
cytoplasm
endoplasmic reticulum
Golgi apparatus
lysosomes
mitochondria
nucleus
nucleoli
plasma (cell) membrane
ribosomes

1. Small granules in the cytoplasm that release energy in the cell ______________ 1.
2. The sticky liquid in which the nucleus and organelles are suspended; that part of the cell between the plasma membrane and the nucleus ______________ 2.
3. The protective membrane that covers the cell; determines what molecules enter and leave the cell; has other functions ______________ 3.
4. Tiny bubblelike structures that contain powerful digestive enzymes to digest and destroy particles or molecules that have invaded the cell ______________ 4.
5. Dense, ball-shaped structure in the center of the cell that controls and regulates the metabolic activities and reproduction of the cell ______________ 5.
6. System of interconnected channels that extend from the cytoplasmic membrane to the nuclear membrane ______________ 6.
7. Flattened sacs or channels near the nucleus of the cell where carbohydrate molecules are synthesized and combined with protein to form glycoproteins ______________ 7.
8. Pairs of cylindrical structures that lie at right angles to each other; important in cell division ______________ 8.
9. Structures within the nucleus composed primarily of RNA (ribonucleic acid); may synthesize ribosomal RNA ______________ 9.
10. Bodies attached to the endoplasmic reticulum; contain ribonucleic acid (RNA) and synthesize protein ______________ 10.
11. The "partitions" of the inner membrane of the mitochondria; contain the enzymes that bring about the release of energy ______________ 11.
12. Granules in the nucleus that contain DNA (deoxyribonucleic acid), important in the transmission of hereditary traits ______________ 12.

Suggested Activity #4: Identification of Abdominal Regions UNIT 1

Objective: To identify the abdominal regions

Materials: Model or chart of abdominal regions
Figures 7 and 8

Procedure:

1. If a model or chart is available, locate the indicated regions.
2. Students will prepare two sketches of the abdominal surface. First, they will show and correctly label abdominal regions using a single vertical line and horizontal line through the umbilicus.
3. Second, they will show and correctly label the nine abdominal regions that are formed by two vertical and two horizontal lines. The vertical lines are drawn on each side through the center of the nipples. The top horizontal line is beneath the ribs, and the bottom horizontal line is just below the iliac crests.

Results: Student sketches should show the following:

Sketch 1
right upper quadrant
left upper quadrant
right lower quadrant
left lower quadrant

Sketch 2
right hypochondriac
epigastric
left hypochondriac
right lumbar
umbilical
left lumbar
right inguinal
hypogastric
left inguinal

Suggested Activity #5: Identification of Body Cavities

Objective: To locate body cavities

Materials: Model or chart (if available)
Figure 9

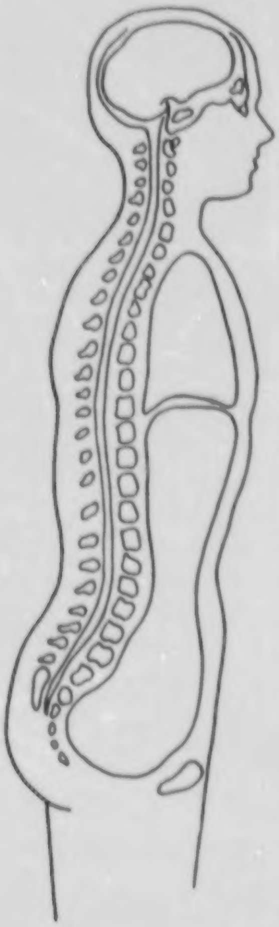
Procedure: 1. Locate the following body cavities on a model or chart:

dorsal
cranial
spinal
ventral

thoracic
pleural
pericardial
abdominopelvic

2. Review the body cavities on figure 9.

Results: Identify the body cavities on the figure without using references.



Suggested Activity #6: Use of Directional Terms to Locate Body Parts

Objective: To become familiar with terms used to locate body parts

Materials: Figure 6, "Terms to Locate Body Parts," to be used with unlabeled diagram of body
Models or charts to use in demonstrating use of terms

Procedure:

1. Demonstrate use of terms by locating body parts on models or charts.
2. Practice use of terms using figure 6.

Results:

1. Complete the following statements:
   a. The fingertip is ________________________ to the hand.
   b. The hand is ________________________ to the finger.
   c. The head is ________________________ to the neck.
   d. The leg is ________________________ to the thigh.
   e. The spinal cavity is ________________________ to the abdominal cavity.
   f. The stomach, intestines, and liver are ________________________ organs.
   g. The lungs are ________________________ to the sternum.
   h. The navel is ________________________ because it is toward the midline.
   i. The skin is ________________________ as opposed to the bone.
   j. The heart is ________________________ to the vertebrae.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. s
2. c
3. i
4. j
5. u
6. n
7. p
8. a
9. q
10. e
11. b
12. l
13. k
14. m
15. h
16. o
17. r
18. t
19. f
20. d
21. g

Suggested Activity #2: Identification of Parts of the Cell

Students should label the parts of the cell as shown in figure 3 in the student's manual.

Suggested Activity #3: Summary of Cell Activities

1. mitochondria
2. cytoplasm
3. plasma (cell) membrane
4. lysosomes
5. nucleus
6. endoplasmic reticulum
7. Golgi apparatus
8. centrosomes
9. nucleoli
10. ribosomes
11. cristae
12. chromatin

Suggested Activity #4: Identification of Abdominal Regions

See figures 7 and 8 for location of regions and correct labels.

Suggested Activity #5: Identification of Body Cavities

See figure 9 for correct labels.

Suggested Activity #6: Use of Directional Terms to Locate Body Parts

1. a. distal
   b. proximal
   c. superior
   d. inferior
   e. posterior
   f. visceral
   g. lateral
   h. medial
   i. superficial
   j. anterior

TEST / UNIT 1

The Organization and General Plan of the Body

I. Choose the correct term for the following definitions. Use letter answers.

_____ 1. the sum of the chemical processes of the body

a) metabolism b) hemopoietic c) pinocytosis d) genetic

_____ 2. living particles contained in the cytoplasm of the cell (little organs)

a) vesicle b) cilia c) organelles d) cristae

_____ 3. standing erect with arms at the sides and palms forward

a) inguinal b) permeable c) lumbar d) anatomic position

_____ 4. region over the pit of the stomach

a) hypochondrium b) epigastrium c) inguinal d) umbilicus

_____ 5. small sac or bladder containing fluid; a blister

a) pleurae b) phagocytosis c) vesicle d) cristae

_____ 6. allows the passage of substances, as through a membrane

a) permeable b) mitosis c) pinocytosis d) hemopoietic

_____ 7. single whiplike extension from the main body of some cells; used in locomotion

a) cilia b) microvilli c) organelle d) flagellum

_____ 8. region of the back between the ribs and pelvic girdle

a) lumbar b) cranial c) epigastrium d) hypochondrium

_____ 9. the engulfing and destruction of foreign particles or bacteria by some cells

a) pinocytosis b) phagocytosis c) metabolism d) mitosis

_____ 10. membranes that cover the lungs and line the chest wall

a) genetic b) pleurae c) mitosis d) flagellum

II. Complete the following statements.

1. The study of the structure of the body is ________________ 1.

2. The study of the function of the body is ________________ 2.

3. The study of the cells is ________________ 3.

4. The metabolic process in which complex compounds are broken down, usually with the release of energy, is ________________ 4.

5. Energy is released in the cell by the ________________ 5.

6. Protein synthesis in the cell takes place in the ________________ 6.

7. The nucleus controls and regulates metabolic activity and ________________ in the cell. ________________ 7.

8. Three types of projections from the cell are microvilli, flagella and ________________ 8.

9. Four kinds of tissue are epithelial, muscle, connective, and ________________ 9.

10. The type of tissue that covers organs, lines cavities, and forms glands is ________________ 10.

11. Bone, blood, fat, and blood-building tissue are all examples of ________________ tissue. ________________ 11.

12. Three types of muscle tissue are visceral (smooth), cardiac, and ________________ 12.

13. In locating body parts, the term for the midline of a structure is ________________ 13.

14. The term that means "toward the feet, lower, or below" is ________________ 14.

15. The term that means "away from the point of origin" is ________________ 15.

16. The dorsal body cavity is divided into the spinal cavity and the ________________ cavity which houses the brain. ________________ 16.

17. The pleural cavities are divisions of the ________________ cavity. ________________ 17.

18. Three body planes are median, frontal, and ________________ 18.

III. List the levels of organization of the body beginning with the chemical level of atoms and molecules.

1. chemical level
2. ______________________
3. ______________________
4. ______________________
5. ______________________

IV. Name the nine systems of the body.

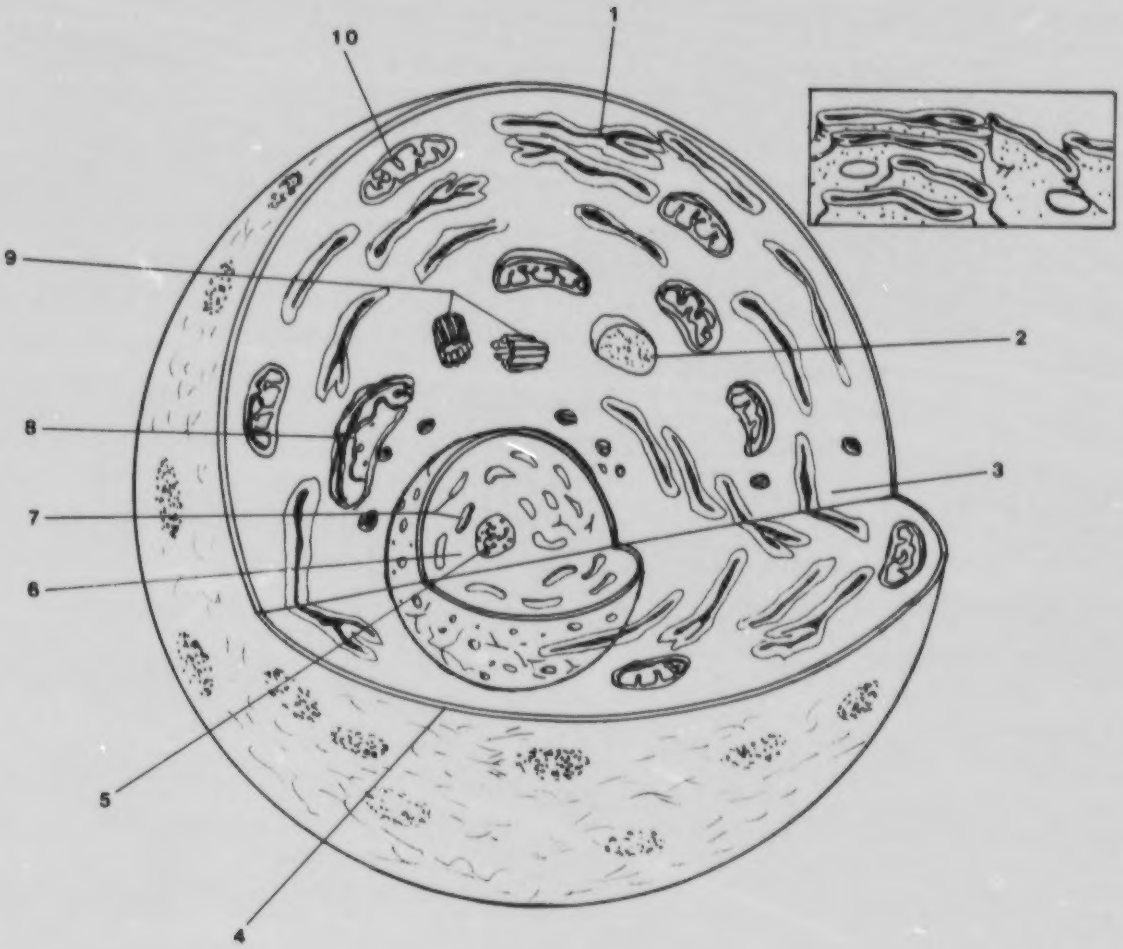
1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________

V. Identify the numbered parts of the diagram of the cell. Write your answers on this page.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________

VI. Give three functions of the plasma membrane.

1. ____
2. ____
3. ____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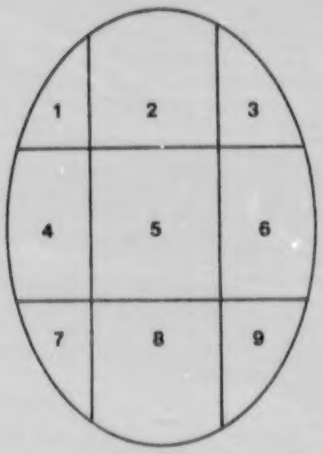
VII. Write the names of the numbered parts of the diagram of the abdominopelvic area.

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________



ANSWERS TO TEST

I. Terms and definitions

1. a
2. c
3. d
4. b
5. c
6. a
7. d
8. a
9. b
10. b

II. Completion statements

1. anatomy
2. physiology
3. cytology
4. catabolism
5. mitochondria
6. ribosomes
7. reproduction
8. cilia
9. nerve
10. epithelial
11. connective
12. skeletal
13. medial
14. inferior
15. distal
16. cranial
17. thoracic
18. transverse

III.
1. chemical level
2. cells
3. tissues
4. organs
5. systems
6. organism

IV.
1. skeletal
2. muscular
3. digestive
4. nervous
5. circulatory
6. urinary
7. respiratory
8. reproductive
9. endocrine

V.
1. endoplasmic reticulum (with ribosomes)
2. lysosome
3. cytoplasm
4. plasma membrane
5. nucleolus
6. nucleus
7. chromatin granules
8. Golgi apparatus
9. centrioles
10. mitochondria

VI. Any of the following:
1. determines the entry of molecules into the cell
2. identifies cells of each individual
3. sends and receives messages
4. cell membrane of white blood cells acts as an antibody

VII.
1. right hypochondriac
2. epigastric
3. left hypochondriac
4. right lumbar
5. umbilical
6. left lumbar
7. right inguinal
8. hypogastric
9. left inguinal

Unit 2

Skeletal System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the skeletal system;
2. give the functions of the skeletal system;
3. describe two types of bone tissue;
4. name, locate, and give the function of each part of a long bone;
5. give the materials required for building bone;
6. describe the different types of bones;
7. identify bones in the axial and appendicular skeletons;
8. identify specific bones on a model or diagram;
9. tell about the role of cartilage in the skeletal system;
10. name and describe five types of bone fractures;
11. describe six types of joints;
12. explain types of movement at joints; and
13. describe common bone diseases.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification of Bones"

Study of the diagram or model of the skeleton and identification of the bones will enhance the descriptions given in the text.

Suggested Activity #3: "Demonstration of Mineral Content of Bone"

The experiment points out the content of bone and provides experience in laboratory procedures.

Suggested Activity #4: "Demonstration of Joint Movement"

This procedure demonstrates joint movement and also provides experience in laboratory procedures involving a partner.

Suggested Activity #5: "Identification of Bone Diseases and Disorders"

This activity provides practice in recognition of the correct terms to match definitions. Reading the definitions for identification reinforces recognition.

Suggested Activity #6: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 2

Review Questions

1. What are five general functions of the skeletal system?
2. Name three examples of body parts protected by bone.
3. What are two minerals that give bone its characteristic hardness?
4. Describe the appearance of cancellous bone tissue.
5. What kind of bone marrow is found in cancellous bone?
6. Describe the microscopic appearance of compact bone tissue.
7. Where are Haversian canals found?
8. What are the horizontal channels through compact bone called?
9. What is the function of Haversian and Volkmann's canals?
10. What is the difference between osteoblasts and osteoclasts?
11. Name three body requirements for building bone.
12. Identify the following parts of a long bone:
    a. diaphysis
    b. epiphysis
    c. periosteum
    d. medullary cavity
    e. articular cartilage
13. What are five broad groups of bones?
14. Describe and locate sesamoid bones.
15. Identify axial and appendicular skeletons.
16. Describe the following bone fractures:
    a. simple
    b. compound
    c. greenstick
    d. comminuted
    e. spiral
17. Describe the steps by which broken bones heal.
18. What are three characteristics of arthritis?
19. Define **bursa.**

ANSWERS TO REVIEW QUESTIONS

1. (1) support
   (2) movement
   (3) protection
   (4) production of blood cells
   (5) storage of fat and mineral salts
2. almost any internal part—the text names brain, spinal cord, heart, and lungs
3. calcium and phosphorus
4. Cancellous bone tissue has many open spaces, and thus a spongy appearance.
5. red
6. It appears as concentric circles.
7. They run longitudinally throughout compact bone.
8. Volkmann's canals
9. They provide transportation for food, oxygen, metabolic wastes, and a pathway for nerves.
10. Osteoblasts are cells that form bone and deposit calcium. Osteoclasts are bone cells that are thought to remove calcium from bone.
11. (1) compounds of calcium and phosphorus
    (2) vitamin D
    (3) hormones
12. a. diaphysis—long, main portion or shaft of bone
    b. epiphysis—ends of long bones
    c. periosteum—white, fibrous covering on the outer surface of bone
    d. medullary cavity—the hollow shaft of long bones
    e. articular cartilage—cartilage that covers the epiphyses of bones where they form a joint
13. (1) long bones
    (2) short bones
    (3) flat bones
    (4) irregular bones
    (5) sesamoid bones
14. small, rounded bones found next to joints
15. The **axial** skeleton includes the skull, vertebral column, ribs, sternum, bones of the ear and hyoid, or those bones arranged on the longitudinal axis of the body. The **appendicular** skeleton is made up of the bones of the appendages or upper and lower extremities.
16. a. simple—the bone is broken but there is no external wound as a result of the injury.
    b. compound—the bone is broken, skin and soft tissue are torn, and the broken ends of the bone protrude through the injured tissue and skin.
    c. greenstick—part of the bone tissue is broken while the remaining portion is bent.
    d. comminuted—bone is splintered at the site of the injury, and small pieces of the bone may be embedded in the tissue surrounding the main fragments.
    e. spiral—the bone is twisted apart with a resulting fracture.
17. First, blood resulting from the injury forms a clot about the injured bone tissue. Then osteoblasts form a loosely woven bone around the injured bone ends. Finally, bone is laid down to knit the fractured ends together again.
18. (1) inflammation of the bones at the joints
    (2) pain
    (3) changes in bone structure
19. A bursa is a sac containing fluid which lubricates the joint.

Suggested Activity #1: Practice with New Terms UNIT 2

Match the following terms with the definitions using letter answers.

_____ 1. connective tissue that attaches muscles to bones

_____ 2. the hollow shaft of long bones

_____ 3. channels that run longitudinally through compact bone

_____ 4. joint that is slightly movable

_____ 5. bone cell that destroys bone tissue

_____ 6. an immovable joint

_____ 7. injury or wound caused by external force or violence

_____ 8. lining of the medullary canal of bones; made primarily of osteoblasts and osteoclasts

_____ 9. white, fibrous protective covering on outer surface of bone

_____ 10. small, rounded bones found next to joints that help eliminate friction and increase efficiency of hinge joints

_____ 11. extremely fat

_____ 12. the ends of long bones; covered with articular cartilage at joints

_____ 13. sac or cavity around bones in joints or between tendons and bones

_____ 14. type of bone tissue that is hard, dense, and without open spaces

_____ 15. channels that run horizontally through compact bone; they extend from the periosteum to the Haversian canals

_____ 16. bone cell

_____ 17. point at which two bones come together; a joint

a. amphiarthrosis
b. articulation
c. bursa
d. cancellous bone tissue
e. cartilage
f. compact bone tissue
g. diaphysis
h. diarthrosis
i. endosteum
j. epiphysis
k. Haversian canals
l. ligament
m. matrix
n. medullary cavity
o. nutrient
p. obese
q. osteoblast
r. osteoclast
s. osteocyte
t. periosteum
u. sesamoid
v. synarthrosis
w. tendon
x. trauma
y. Volkmann's canals

_____ 18. food substance that supplies the body with elements used in metabolism; the usable part of food

_____ 19. type of bone tissue characterized by many open spaces among bone processes; has a spongelike appearance

_____ 20. bone cells that form bone

_____ 21. connective tissue that binds bones together at the joints

_____ 22. joint that is freely movable

_____ 23. basic substance of which a thing is made or develops; intercellular material of a tissue

_____ 24. specialized connective tissue; made up of cells (chondrocytes) embedded in a collagenous matrix; tough, flexible material that makes up part of the skeleton

_____ 25. long, main portion or shaft of a bone

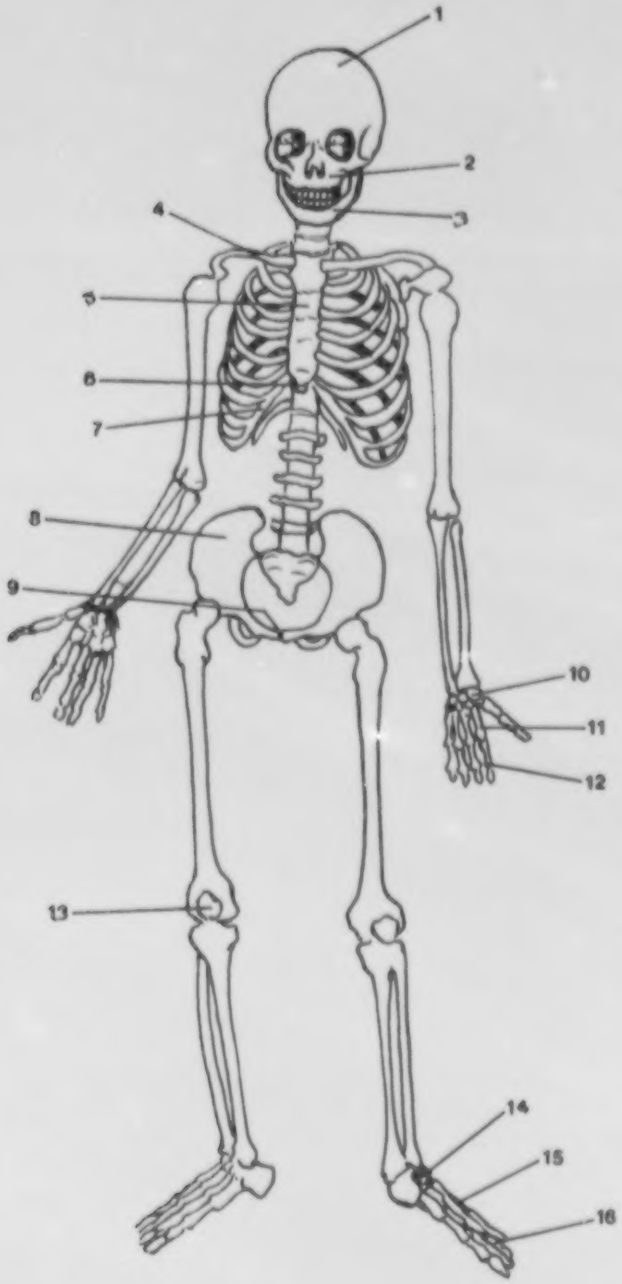
Suggested Activity #2: Identification of Bones

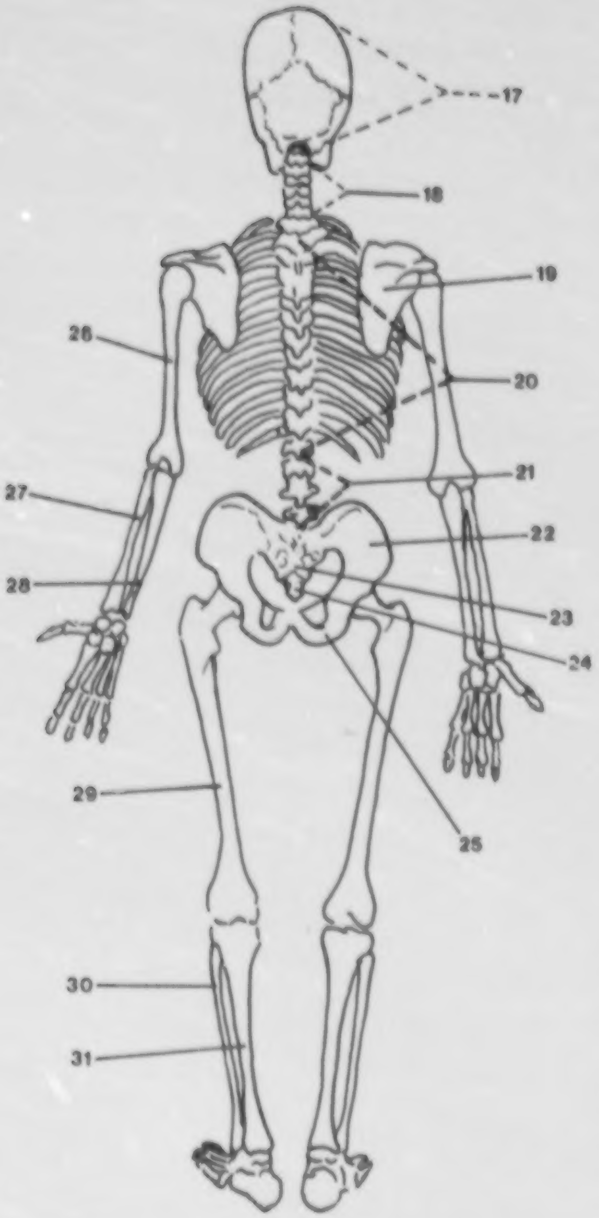
Objective: To learn to identify bones of the skeletal system

Materials: Skeleton model (if available) or
Large chart of skeleton
Figure 5 labeled and without labels

Procedure: Using materials at hand, review the names of the bones of the skeleton. Use Figure 5 as a reference. Then write the appropriate names of bones on the unlabeled diagram.

Results: Correct labels should be written on unlabeled diagram.

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Suggested Activity #3: Demonstration of Mineral Content of Bone UNIT 2

Objective: To demonstrate the presence of minerals in bone

Materials:
Long bones of small animal; chicken is satisfactory
Vinegar, 500 ml
Beaker, 500 ml
Fisher burner
Tripod
Tongs
Evaporating dish

Procedure:

1. Place long bone in beaker filled with vinegar to cover the bone.
2. Incubate at room temperature.
3. Check bone at 24-hour intervals to see what changes have occurred.
4. Break a second long bone into conveniently small pieces, and place in evaporating dish.
5. Heat only until powdery residue remains.

Results:

1. Describe the changes in the bone soaked in vinegar.
2. What do you think the residue from burning the bone is made up of?

Suggested Activity #4: Demonstration of Joint Movement

Objective: To demonstrate joint action using a live model

Materials: Information on types of joints and joint action
Pair of students

Procedure: One student names joint action as it is demonstrated. The other student performs activities and describes the specific action as it is performed. The demonstration could include the following movements:

1. flexion
2. extension
3. abduction
4. adduction
5. rotation
6. circumduction

Results: Procedure should be evaluated by the instructor.

Suggested Activity #5: Identification of Bone Diseases and Disorders UNIT 2

Objective: To learn to identify bone diseases and disorders.

Directions: Choose the correct term for the descriptions from the list below.

arthritis
bunion
bursitis
dislocation
fracture
kyphosis
lordosis
osteitis
osteomyelitis
osteoporosis
rickets
scoliosis
spina bifida
sprain
tuberculosis

1. inflammation or infection of the bone ____________ 1.
2. a break in a bone ____________ 2.
3. the displacement of a bone from a joint tearing ligaments, tendons, and capsules ____________ 3.
4. inflammation of the bones at the joints, usually with pain and changes in bone structure ____________ 4.
5. invasion of bone by tubercle bacilli ____________ 5.
6. congenital defect in which the vertebrae fail to unite at the midline ____________ 6.
7. condition in which bones fail to grow and growth is hampered, usually due to a deficiency of vitamin D and phosphorus in the diet ____________ 7.
8. bone infection that involves bone marrow ____________ 8.
9. increase in natural curvature of the spinal column with resulting hunchback appearance ____________ 9.
10. inflammation of the bursa ____________ 10.
11. side-to-side curvature of the spinal column ____________ 11.
12. wrenching of a joint with injury to ligaments ____________ 12.
13. abnormal lateral displacement of the big toe causing inflammation and thickening of the bursa ____________ 13.
14. condition in which bones become softer and more brittle, thus more liable to fracture because of loss of mineral content; usually associated with aging ____________ 14.
15. exaggerated inward curvature in the lumbar region of the spinal column ____________ 15.

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information on the extent of research and guidelines for writing the paper.

Suggested topics are:

- Athletic Injuries and Protective Devices
- Skeletal Changes in Aging
- Bone Transplants and Grafts
- The Living Bank
- Careers Related to the Skeletal System (Include Physical Therapy, Orthotics, Occupational Therapy, Medical Illustrator, Anatomist, Physiologist Physician (Orthopedist), Doctor of Osteopathy, or Podiatrist)

The topics should reflect the student's interest. The topic could provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. w
2. n
3. k
4. a
5. r
6. v
7. x
8. i
9. t
10. u
11. p
12. j
13. c
14. f
15. y
16. s
17. b
18. o
19. d
20. q
21. l
22. h
23. m
24. e
25. g

Suggested Activity #2: Identification of Bones

Students should write in the names of the bones as shown in figure 5.

Suggested Activity #3: Demonstration of Mineral Content of Bone

1. The bone will become soft and pliable because the minerals have been dissolved by the vinegar (5% acetic acid). Only bone cells, cartilage, and gelatinous organic deposits remain.

2. The residue is made up of minerals, primarily compounds of calcium and phosphorus.

Suggested Activity #4: Demonstration of Joint Movement

Procedure should be evaluated by the instructor.

Suggested Activity #5: Bone Diseases and Disorders

1. osteitis
2. fracture
3. dislocation
4. arthritis
5. tuberculosis (bone)
6. spina bifida
7. rickets
8. osteomyelitis
9. kyphosis
10. bursitis
11. scoliosis
12. sprain
13. bunion
14. osteoporosis
15. lordosis

Suggested Activity #6: Research Paper

The paper should be evaluated to the satisfaction of the instructor.

TEST / UNIT 2

The Skeletal System

I. Match the following terms with the definitions using letter answers.

____ 1. injury or wound caused by external force or violence

____ 2. bone cells that destroy bone tissue

____ 3. connective tissue that attaches muscles to bones

____ 4. sac or cavity found between bones or between tendons and bones

____ 5. bone cell

____ 6. basic substance of which a thing is made or develops; intercellular material of a tissue

____ 7. specialized connective tissue; made up of cells (chondrocytes) embedded in a matrix of collagen; tough flexible material that makes up part of the skeleton

____ 8. extremely fat

____ 9. point at which two bones come together; a joint

____ 10. type of bone tissue that is hard, dense, and without open spaces

a. articulation
b. bursa
c. cancellous
d. cartilage
e. compact
f. matrix
g. obese
h. osteoclast
i. osteocyte
j. tendon
k. trauma

II. Choose the correct name from those given for each of the following disease descriptions.

1. inflammation or infection of the bone (arthritis, bursitis, osteitis, osteoporosis) ____________ 1.

2. a break in a bone (fracture, dislocation, rickets, sprain) ____________ 2.

3. side-to-side curvature of the spinal column (kyphosis, lordosis, scoliosis, dislocation) ____________ 3.

4. inflammation of the bones at the joints, usually with pain and changes in bone structure (tuberculosis, osteomyelitis, spina bifida, arthritis) ____________ 4.

5. abnormal lateral displacement of the big toe causing inflammation and thickening of the bursa (osteitis, bunion, sprain, arthritis) ____________ 5.

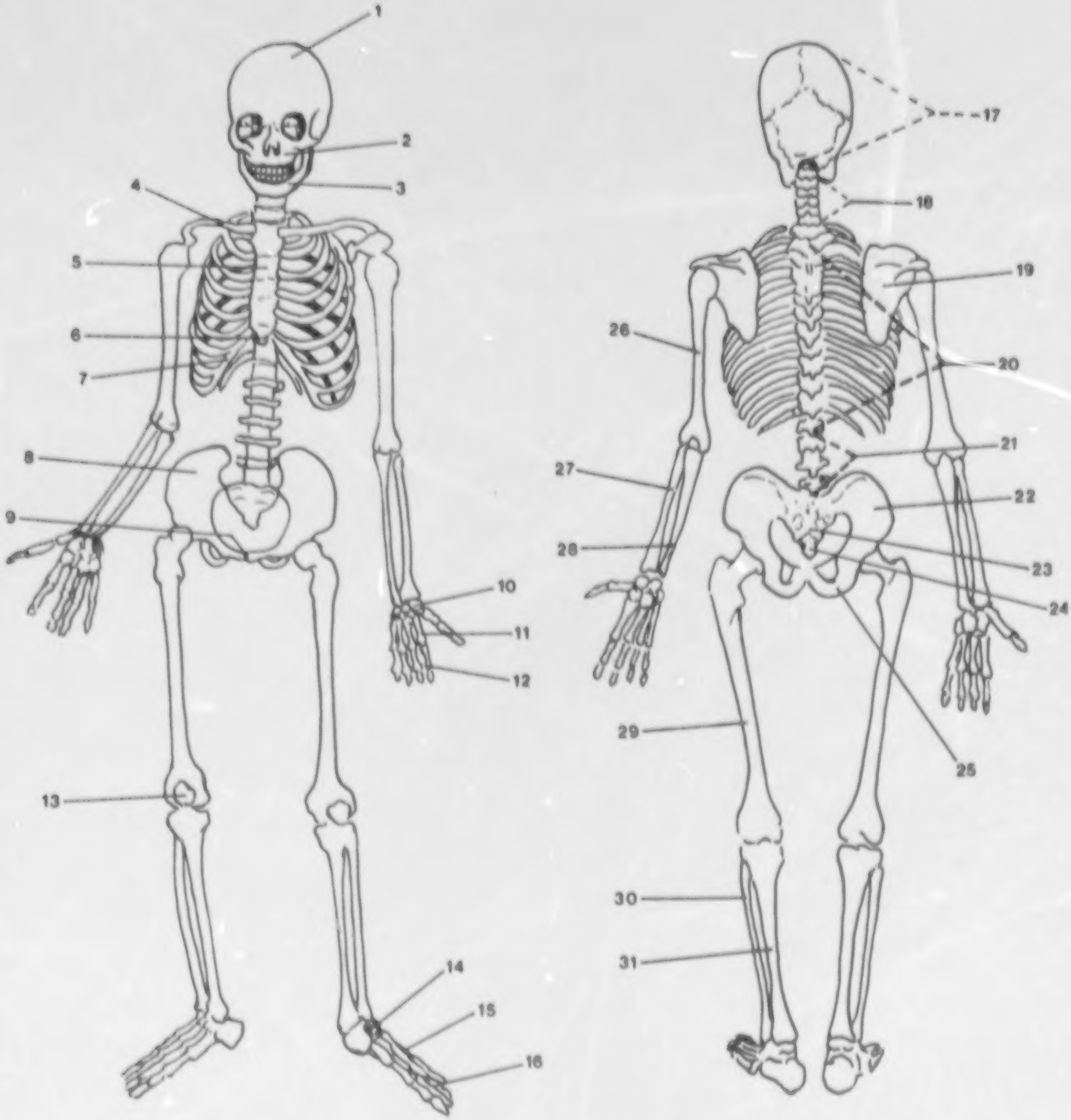
III. Identify the numbered parts shown on the attached diagram of the skeletal system.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________
18. ______________________________
19. ______________________________
20. ______________________________
21. ______________________________
22. ______________________________
23. ______________________________
24. ______________________________
25. ______________________________
26. ______________________________
27. ______________________________
28. ______________________________
29. ______________________________
30. ______________________________
31. ______________________________

IV. Complete the following statements.

A. Complete the following statements about the parts of the bone.

1. The long, main portion or shaft of a long bone is the ______________ 1.
2. The ends of long bones are the ______________ 2.
3. The white, fibrous, protective covering on the outer surface of bone is the ______________ 3.
4. The hollow shaft of a long bone is the ____________________ cavity. ______________ 4.
5. The endosteum is made primarily of two types of bone cells, osteoblasts and ______________ 5.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B. Complete the following statements about joints and movement.

1. A joint that is freely movable is a (an) ____________ 1.
2. An example of an immovable joint or synarthrosis is ____________ 2.
3. A motion that moves a bone away from the body is ____________ 3.
4. The motion that straightens a joint is ____________ 4.
5. Types of joints classified by their function or movement include ball and socket, gliding, pivot, partially movable, immovable, and ____________ 5.

C. Complete the following statements.

1. Two types of bone tissue are cancellous and ____________ 1.
2. The Haversian canals and ____________ transport minerals among bone cells. ____________ 2.
3. The body requires hormones, vitamins, and ____________ to build bone. ____________ 3.
4. Bones are classified as to size and shape as long bones, short bones, flat bones, irregular bones, and ____________ 4.
5. The type of bone fracture in which the bone is broken, the skin and soft tissue are torn, and the broken ends of the bone protrude through the tissue and skin is a (an) ____________ 5.

V. Tell whether each of the following bones is a part of the axial or appendicular skeleton.

1. carpals
2. clavicle
3. ethmoid
4. femur
5. fibula
6. frontal
7. humerus
8. hyoid
9. ilium
10. incus
11. ischium
12. lacrimal
13. maleus
14. mandible
15. maxilla
16. metacarpals
17. nasal bone
18. occipital
19. palatine
20. parietal
21. patella
22. phalanges
23. pubis
24. radius
25. ribs
26. scapula
27. sphenoid
28. stapes
29. sternum
30. tarsals
31. temporal
32. tibia
33. ulna
34. vertebrae
35. zygomatic

Axial	Appendicular
1. ____________	Ex. carpals
2. ____________	____________
3. ____________	____________

	Axial	Appendicular
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
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19.		
20.		
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22.		
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24.		
25.		
26.		
27.		
28.		
29.		
30.		

	Axial	Appendicular
31.		
32.		
33.		
34.		
35.		

VI. List four functions of the skeletal system:

1. ____________________
2. ____________________
3. ____________________
4. ____________________

ANSWERS TO TEST

I.
1. k
2. h
3. j
4. b
5. i
6. f
7. d
8. g
9. a
10. e

II.
1. osteitis
2. fracture
3. scoliosis
4. arthritis
5. bunion

III.
1. cranium (skull)
2. maxilla
3. mandible
4. clavicle
5. sternum
6. xiphoid process
7. costal cartilage
8. innominate bone (ilium)
9. pubis
10. carpals
11. metacarpals
12. phalanges
13. patella
14. tarsals
15. metatarsals
16. phalanges
17. skull
18. cervical vertebrae
19. scapula
20. thoracic vertebrae
21. lumbar vertebrae
22. ilium
23. sacrum
24. coccyx
25. ischium
26. humerus
27. radius
28. ulna
29. femur
30. fibula
31. tibia

IV. A.
1. diaphysis
2. epiphyses
3. periosteum
4. medullary
5. osteoclasts

B.
1. diarthrosis
2. bones of adult cranium
3. abduction
4. extension
5. hinge

C.
1. compact
2. Volkmann's
3. minerals (calcium and phosphorus)
4. sesamoid
5. compound

V.

	Axial	**Appendicular**
1.		carpals
2.		clavicle
3.	ethmoid	
4.		femur
5.		fibula

	Axial	Appendicular
6.	frontal	
7.		humerus
8.	hyoid	
9.		ilium
10.	incus	
11.		ischium
12.	lacrimal	
13.	maleus	
14.	mandible	
15.	maxilla	
16.		metacarpals
17.	nasal bone	
18.	occipital	
19.	palatine	
20.	parietal	
21.		patella
22.		phalanges
23.		pubis
24.		radius
25.	ribs	
26.		scapula
27.	sphenoid	
28.	stapes	
29.	sternum	
30.		tarsals
31.	temporal	
32.		tibia
33.		ulna
34.	vertebrae	
35.	zygomatic	

VI. Any four of the following:

1. movement (muscle attachment)
2. support (provides body form and shape)
3. protection of body parts
4. production of blood cells
5. storage of fats and mineral deposits

Unit 3

The Muscular System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the muscular system;
2. list three functions of muscles;
3. list three types of muscles;
4. give the general structure of a skeletal muscle;
5. list the parts of a muscle cell;
6. explain how a muscle contracts;
7. discuss energy release in skeletal muscles;
8. explain "oxygen debt";
9. explain the origin and insertion of skeletal muscles;
10. give ways in which muscles are named;
11. identify several muscles from a diagram, chart, or model;
12. identify common disorders of muscles;
13. demonstrate three sites for intramuscular injection; and
14. tell what drug implantation means.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification of Muscles"

Study of the models, charts, and text and identification of muscles will enhance the written descriptions. The instructor should determine which muscles should be memorized, if any.

Suggested Activity #3: "Identification of Muscle Diseases and Disorders"

This activity is designed to make the student familiar with the names and descriptions of common muscle disorders and diseases. It is not meant to be comprehensive. Reading the descriptions for identification reinforces recognition.

Suggested Activity #4: "Athletic Trainer as Guest Speaker"

A guest speaker, particularly one as well known to most students as the athletic trainer, is welcomed by most classes. Students enjoy the change of pace, and the trainer will have valuable expertise in kinesiology to share. Most students will feel free to ask questions of a speaker they already know.

Suggested Activity #5: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 3

Review Questions

1. What are three functions of muscles?
2. What are three types of muscles?
3. Distinguish between the following:
   a. epimysium
   b. perimysium
   c. endomysium
4. For each of the following cell parts, give the corresponding name of a muscle cell part:
   a. plasma membrane
   b. cytoplasm
   c. endoplasmic reticulum
5. Explain briefly how a skeletal muscle contracts.
6. What is the difference between **aerobic** and **anaerobic** respiration?
7. Define **oxygen debt**.
8. Define **origin** and **insertion** of a muscle.
9. List six terms that indicate specific muscle functions, and give the activity of each.
10. What are seven types of descriptive terms used in naming muscles?
11. To which term do each of the following names relate?
    a. flexor
    b. deltoid
    c. sternocleidomastoid
    d. biceps
    e. tibialis
    f. gluteus maximus
    g. rectus
12. What is an **aponeurosis**?
13. What are three sites commonly used for intramuscular injection?
14. What is meant by an "implantable" drug system?

ANSWERS TO REVIEW QUESTIONS

1. (1) movement
   (2) to maintain body position or posture
   (3) to maintain a constant body temperature by heat production
2. (1) skeletal (voluntary, striated)
   (2) smooth (visceral, involuntary)
   (3) cardiac
3. a. epimysium—covers **bundles of muscle fibers**
   b. perimysium—fibrous sheath that surrounds **individual muscle fibers**
   c. endomysium—covers **individual muscle cells**
4. a. sarcolemma
   b. sarcoplasm
   c. sarcoplasmic reticulum
5. A nerve impulse reaches a myofibril, stimulating it to contract. Energy is released. Thick myosin myofilaments and thin actin myofibrils slide over one another. As the myofibrils move, the sarcomere contracts. With the contraction of multiple sarcomeres, the muscle contracts.
6. **Aerobic** respiration is cellular respiration in which atmospheric oxygen combines with glucose in the cells with the release of energy. **Anaerobic** respiration is cellular respiration that takes place when there is a lack of atmospheric oxygen. Pyruvic acid breaks down to release energy. Lactic acid is formed.
7. **Oxygen debt** occurs when the muscles must depend on anaerobic respiration with the release of lactic acid for energy, usually because of extra demands for energy in strenuous exercise. The lactic acid causes muscle fatigue and an increase in breathing and heart rate. Thus, the amount of oxygen taken into the body is increased. During rest, because the intake of oxygen is increased and the demand is lessened, the "debt" is gradually paid.
8. The **origin** of a muscle is the more fixed end, or attachment. The **insertion** is the place of attachment of a muscle to a bone which it moves.
9. (1) flexor—muscle that bends a joint
   (2) extensor—muscle that extends a part or increases the angle of a joint
   (3) abductor—muscle that moves a part away from the midline of the body
   (4) adductor—muscle that moves a part toward the midline of the body
   (5) rotator—muscle that revolves a part on its axis
   (6) sphincter—circular muscle that closes an opening
10. (1) action
    (2) shape
    (3) origin and insertion
    (4) number of divisions
    (5) location
    (6) size
    (7) direction of fibers
11. a. flexor—action
    b. deltoid—shape
    c. sternocleidomastoid—origin and insertion
    d. biceps—number of divisions
    e. tibialis—location
    f. gluteus maximus—size
    g. rectus—direction of fibers
12. An aponeurosis is a flat, fibrous sheet of tissue that serves as an attachment for muscles to bone or other tissue.

13. (1) gluteal
    (2) deltoid
    (3) vastus lateralis

14. It is a system in which drugs are implanted into the body so that a constant drug level may be maintained for a long period of time.

Suggested Activity #1: Practice with New Terms

UNIT 3

Match the following terms with the phrases using letter answers.

____ 1. tissue that covers individual cells in a muscle

____ 2. internal organs enclosed within a cavity; especially abdominal organs

____ 3. a state of equilibrium that the body maintains by constant self-regulating mechanisms

____ 4. a fibrous membrane that covers, supports, and separates muscles

____ 5. cellular respiration in which atmospheric oxygen is used

____ 6. tissue that covers the outside surface of a muscle; fibrous, connective tissue

____ 7. striped; marked by streaks

____ 8. fibrous tissue that attaches muscle to bone (an extension of the epimysium)

____ 9. cellular respiration in which oxygen obtained from chemical reactions is used instead of atmospheric oxygen

____ 10. the more fixed end or attachment of a muscle; as distinguished from its insertion

____ 11. a flat, fibrous sheet of tissue that serves as an attachment for muscles to bones or other tissue

____ 12. the place of attachment of a muscle to a bone which it moves

____ 13. fibrous connective sheath that surrounds individual bundles of muscle fibers

a. aerobic respiration
b. anaerobic respiration
c. aponeurosis
d. endomysium
e. epimysium
f. fascia
g. homeostasis
h. insertion
i. origin
j. perimysium
k. striate
l. tendon
m. viscera

Suggested Activity #2: Identification of Muscles

Objective: To identify and learn the names of some muscles

Procedure: Using available materials such as models, charts, and text illustrations, identify the muscles indicated by letters in the figures. Write their names in the blank spaces.

Posterior Aspect

A. ______________________

B. ______________________

C. ______________________

D. ______________________

E. ______________________

F. ______________________

Anterior Aspect

A. ______________________

B. ______________________

C. ______________________

D. ______________________

E. ______________________

F. ______________________

G. ______________________

H. ______________________

I. ______________________

J. ______________________

K. ______________________

L. ______________________

M. ______________________

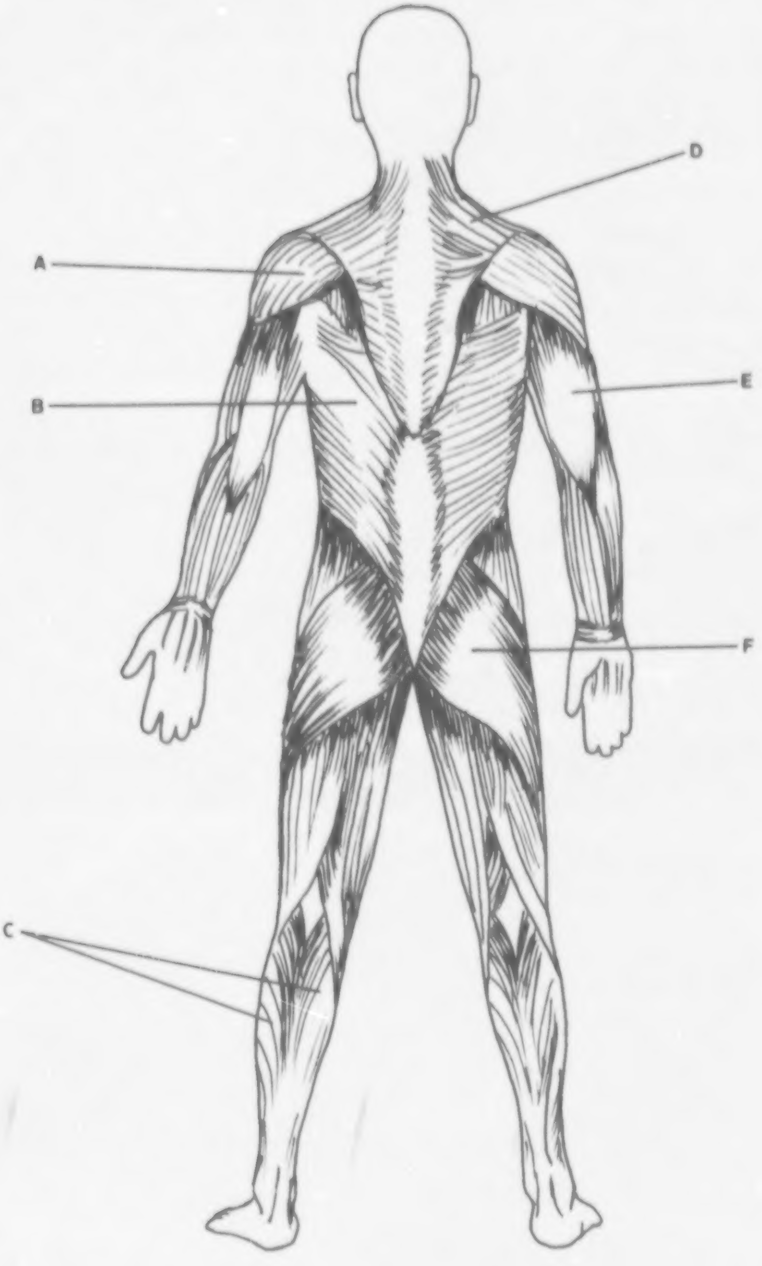
N. ______________________

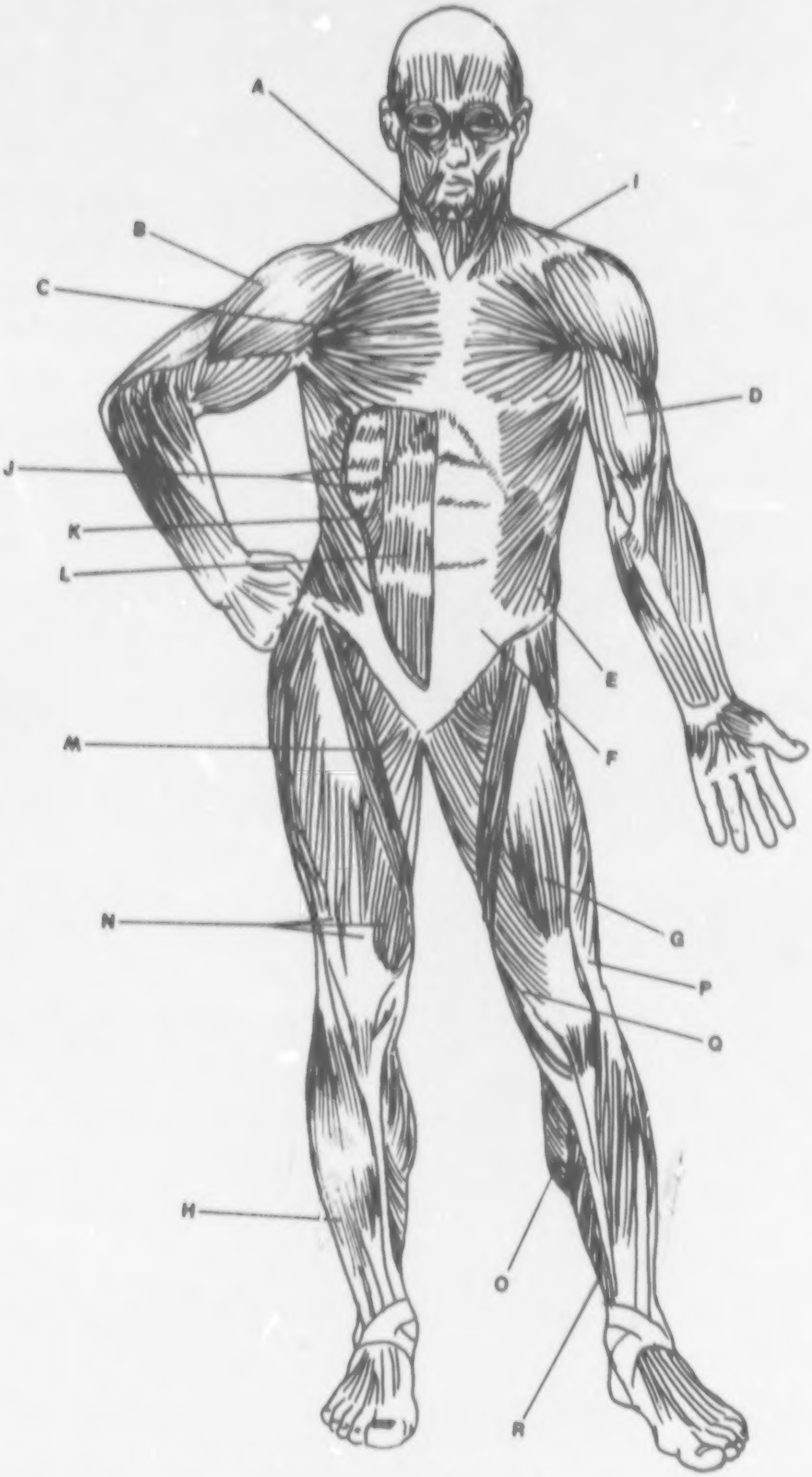
O. ______________________

P. ______________________

Q. ______________________

R. ______________________


D
A
E
B
F
C


A
I
B
C
D
J
K
L
E
M
F
N
G
P
Q
H
O
R

Suggested Activity #3: Identification of Muscle Diseases and Disorders

Objective: To become familiar with the names and descriptions of common diseases and disorders of muscles

Procedure: Write the correct term for the following descriptions in the appropriate blank.

contracture
muscle cramp
muscle spasm
muscular dystrophy
myalgia
myasthenia gravis
myositis

1. inflammation of muscle tissue ______________ 1.
2. disease in which the muscle cells degenerate, and muscles waste away and atrophy; no cause or cure is now known ______________ 2.
3. muscle pain ______________ 3.
4. permanent shortening of a muscle, usually caused by formation of fibrous tissue to replace muscle cells; may occur in immobile patients ______________ 4.
5. painful, spasmodic muscle contraction of longer duration ______________ 5.
6. poorly understood disease with muscle weakness and great fatigue; nerve impulses fail to induce normal muscle contractions ______________ 6.
7. sudden, involuntary muscle contraction of short duration ______________ 7.

Suggested Activity #4: Athletic Trainer as Guest Speaker

Objective: To benefit from the expertise and experience of the athletic trainer in the protection and training of students in athletic events

Procedure: Invite the athletic trainer to speak to the students for 20 to 30 minutes. Suggest that the following topics be covered in the course of the presentation, as well as other topics the trainer feels are pertinent.

- Training to Improve Muscle Strength and Endurance
- Ways to Avoid Muscle Strain and Injury
- Specific Muscles Used in Specific Events

Encourage the speaker to present demonstrations and answer student questions.

Suggested Activity #5: Research Paper

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper.

Suggested topics are:

- Physiatry and Physical Therapy: Careers that Deal with Muscles
- Implantable Drug Delivery Systems
- Demonstration of Muscle Fatigue with Written Explanation
- Report on Progress in Treatment of Progressive Muscular Diseases
- Description of Parental Drug Delivery Systems
- Correlation of Diet to Muscle Strength and Development

Topics should reflect individual student interest. Often the topic can provide the student with information regarding a specific career.

Results: The research paper should be evaluated to the satisfaction of the instructor.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. d
2. m
3. g
4. f
5. a
6. e
7. k
8. l
9. b
10. i
11. c
12. h
13. j

Suggested Activity #2: Identification of Muscles

Posterior Aspect

A. deltoid
B. latissimus dorsi
C. gastrocnemius
D. trapezius
E. triceps brachii
F. gluteus maximus

Anterior Aspect

A. sternocleidomastoid
B. deltoid
C. pectoralis major
D. biceps brachii
E. external oblique
F. aponeurosis (not a muscle)
G. rectus femoris
H. tibialis anterior
I. trapezius
J. intercostals
K. internal oblique
L. rectus abdominus
M. sartorius
N. quadriceps femoris
O. gastrocnemius
P. vastus lateralis
Q. vastus medialis
R. tibialis posterior

Suggested Activity #3: Identification of Muscle Diseases and Disorders

1. myositis
2. muscular dystrophy
3. myalgia
4. contracture
5. muscle cramp
6. myasthenia gravis
7. muscle spasm

Suggested Activity #4: Athletic Trainer as Guest Speaker

There are no answers for this activity. It might be useful to have general class discussion following the presentation, which would give students a chance to relate the information to their own experiences.

Suggested Activity #5: Research Paper

Evaluated to the satisfaction of the instructor.

TEST / UNIT 3

The Muscular System

I. Choose the correct term for the definitions from the list below:

aerobic respiration
anaerobic respiration
aponeurosis
endomysium
epimysium
fascia
homeostasis
insertion
origin
perimysium
striate
tendon
viscera

1. the more fixed end or attachment of a muscle; as distinguished from its insertion ______________ 1.
2. fibrous connective sheath that surrounds individual bundles of muscle fibers ______________ 2.
3. cellular respiration in which atmospheric oxygen is used ______________ 3.
4. tissue that covers the outside surface of a muscle; fibrous connective tissue ______________ 4.
5. striped; marked by streaks ______________ 5.
6. cellular respiration in which atmospheric oxygen is not used; pyruvic acid is the source of energy ______________ 6.
7. a state of equilibrium that the body maintains by constant self-regulating mechanisms ______________ 7.
8. the place of attachment of a muscle to a bone which it moves ______________ 8.
9. a flat, fibrous sheet of tissue that serves as an attachment for muscles to bones or other tissue ______________ 9.
10. fibrous tissue that attaches muscle to bone (an extension of the epimysium) ______________ 10.

II. Give three functions of the muscular system:

1. ______________________________
2. ______________________________
3. ______________________________

III. List three kinds of muscle tissue:

1. ______________________

2. ______________________

3. ______________________

IV. Explain briefly how muscles contract.

V. What chemical substance accumulates in the muscles when "oxygen debt" occurs?

VI. List five types of descriptive terms used in naming muscles. An example is "size."

a. ______________ d. ______________

b. ______________ e. ______________

c. ______________

VII. Name three parts of a muscle cell that correspond to the names of other cells.

a. ______________________________

b. ______________________________

c. ______________________________

VIII. Label the indicated parts of the diagram of the muscles. (Note that some of the letters are omitted)

Posterior Aspect

a. ______________________

c. ______________________

e. ______________________

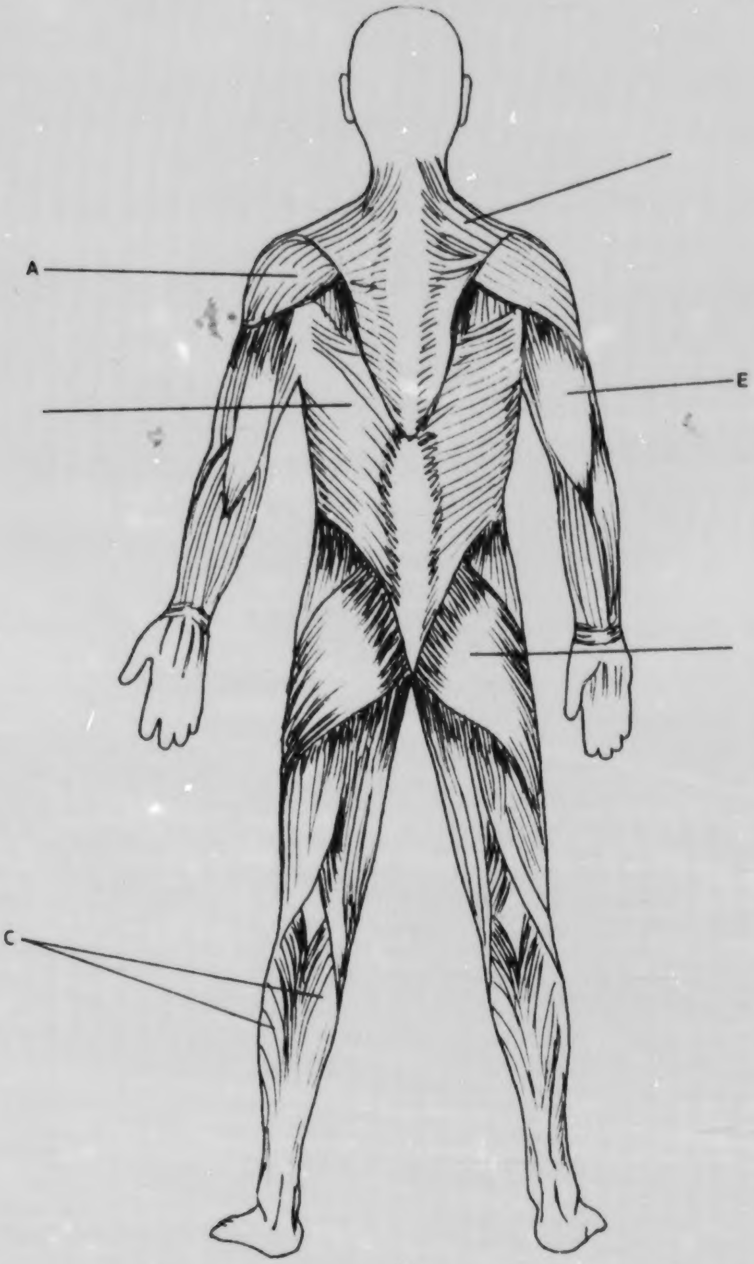
Anterior Aspect

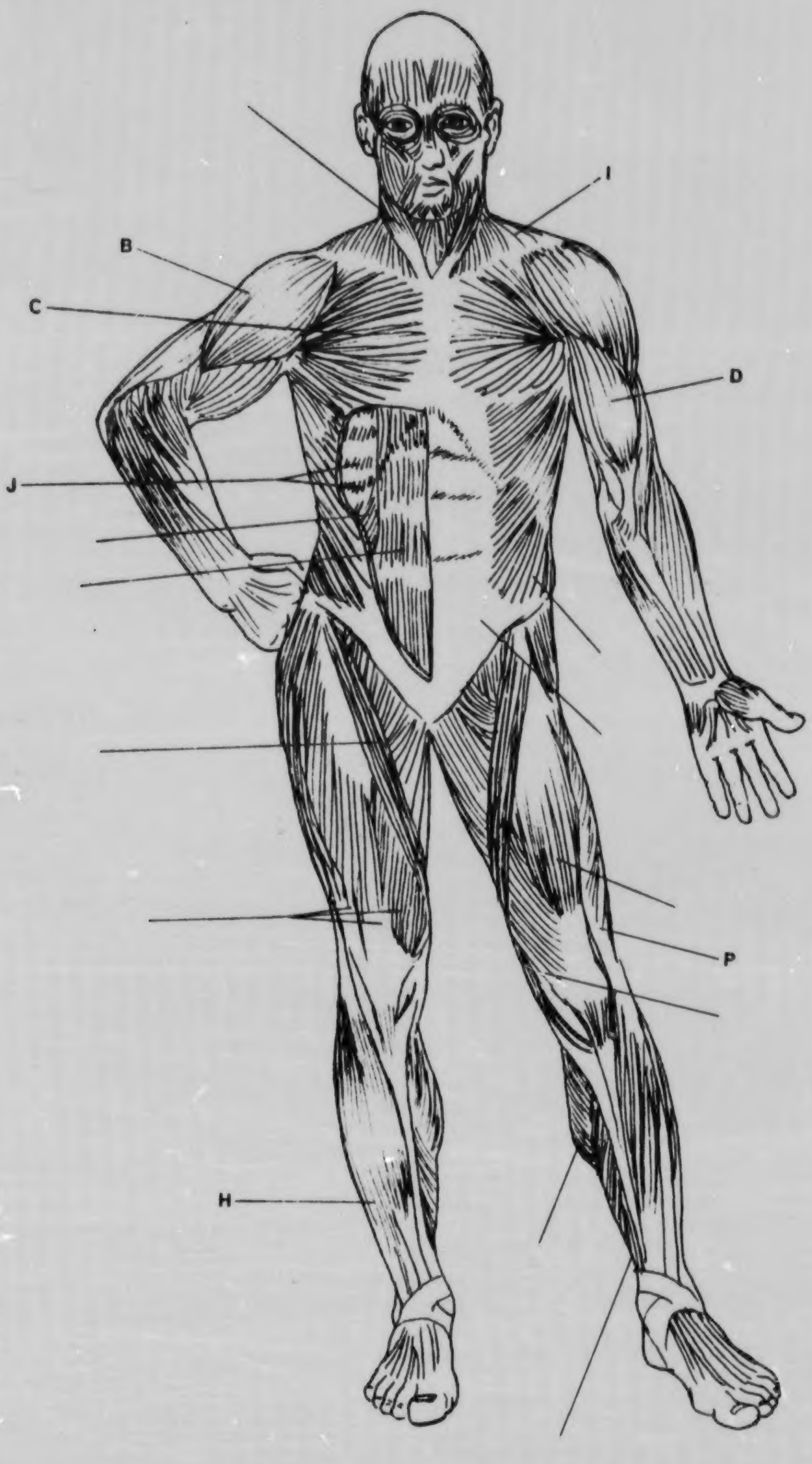
b. ______________________

c. ______________________

d. ______________________

h. ______________________


A
E
C


I
B
C
D
J
P
H

i. ______________________________

j. ______________________________

p. ______________________________

IX. Identify the following descriptions of common muscle diseases or disorders.

1. painful, spasmodic muscle contraction of longer duration ____________ 1.

2. disease in which the muscle cells degenerate, and muscles waste away and atrophy; no cause or cure is now known ____________ 2.

3. muscle pain ____________ 3.

4. permanent shortening of a muscle, usually caused by formation of fibrous tissue to replace muscle cells; may occur in immobile patients ____________ 4.

5. inflammation of muscle tissue ____________ 5.

ANSWERS TO TEST

I.
1. origin
2. perimysium
3. aerobic respiration
4. epimysium
5. striate
6. anaerobic respiration
7. homeostasis
8. insertion
9. aponeurosis
10. tendon

II.
1. movement
2. to maintain a constant body temperature by heat production
3. to maintain body position or posture

III.
1. skeletal (voluntary, striated)
2. smooth (visceral, involuntary)
3. cardiac

IV. (Need not be verbatim)

Nerve impulse reaches a myofibril, stimulating it to contract. Energy is released. Thick myosin myofilaments and thin actin myofibrils slide over one another as the myofibrils move, and the sarcomere contracts. With the contraction of multiple sarcomeres, the muscle contracts.

V. lactic acid

VI. (Any five of the following)
1. action
2. shape
3. origin and insertion
4. number of divisions
5. location
6. direction of fibers

VII. (In any order)
1. sarcolemma
2. sarcoplasm
3. sarcoplasmic reticulum

VIII. **Posterior Aspect**

a. deltoid
b. gastrocnemius
c. triceps brachii

Anterior Aspect

b. deltoid
c. pectoralis major
d. biceps brachii
h. tibialis anterior
i. trapezius
j. intercostals
p. vastus lateralis

IX.
1. cramp
2. muscular dystrophy
3. myalgia
4. contracture
5. myositis

Unit 4

The Digestive System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the digestive system;
2. name and locate the parts of the digestive system;
3. name four types of teeth, and give the function and number of each kind;
4. discuss digestion in the stomach;
5. name the regions of the small intestine;
6. tell how the small intestine is modified to increase its absorption surface;
7. name digestive juices, and give the source and action of each;
8. discuss the function of the large intestine;
9. give the nondigestive functions of the liver;
10. explain the digestive role of the pancreas;
11. identify the omentum, peritoneum, and mesentery; and
12. identify disorders of the parts of the digestive tract.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Identification of the Parts of the Digestive System"

Study of the diagram and/or model of the digestive system and identification of the parts will enhance the descriptions given in the text. In correctly labeling the parts of the digestive system on the diagram, students will learn the location of the individual parts. Also, they will develop a concept of the relation of one part to the others and of the relation of location to function.

Suggested Activity #2: "Word Find Puzzle"

The word find puzzle provides another way for students to become better acquainted with the terms that relate to this lesson. If some students do not enjoy this type of activity, they should not be required to complete the puzzle. Other activities can be substituted. However, many students will enjoy the change in activity.

Suggested Activity #3: "Demonstration of Swallowing (Deglutition)"

This activity will help the student to understand the role of the tongue and larynx in swallowing. They usually enjoy hearing the water enter the stomach. This common activity takes on new significance as students understand the process.

Suggested Activity #4: "Identification of Digestive Juices and Enzymes"

This exercise provides practice in memorization of the names, locations, and actions of important enzymes. You will have to decide whether or not this memorization is important, but it does ensure that students will recognize these enzymes as they continue their study of the digestive system.

Suggested Activity #5: "Chemical Digestion"

This experiment is simple, yet it provides students an opportunity to work in the laboratory. The needed solutions are probably available in the science department: if not, they are easily prepared. Students usually enjoy the clear-cut results. It is important that they understand the changes that take place.

Suggested Activity #6: "Taste Perception"

This experiment is a simple one, but it dramatically demonstrates the location of the taste buds and the importance of the sense of smell in identifying different flavors.

Suggested Activity #7: "Demonstration of the Length of the Digestive Tract"

This activity demonstrates dramatically the length of the digestive tract. It may seem juvenile for your students, but it is usually successful in proving the remarkable length of the digestive tract.

Suggested Activity #8: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 4

Review Questions

1. What is the function of the digestive system?
2. What is the alimentary canal?
3. Name two accessory organs of digestion.
4. What are the four types of permanent teeth, and what is the function of each?
5. Name and locate the three pairs of salivary glands.
6. What are three functions of the tongue?
7. What are the four tastes detected by the tongue?
8. How are other tastes achieved?
9. What is the function of the tonsils?
10. How is food moved through the esophagus?
11. Name the two sphincters of the stomach.
12. What are **rugae**?
13. What are the four basic functions of the stomach?
14. Name the three divisions of the small intestine and the approximate length of each.
15. What is the overall function of the small intestine?
16. What are three ways in which the small intestine is modified to increase its surface area?
17. Where in the small intestine is digested food taken into the bloodstream?
18. What are three sources of digestive secretions in the small intestine?
19. Name the parts of the large intestine, in order, from the ileocecal valve to the anus.
20. What is the cecum?
21. Where is the vermiform appendix located?
22. What are three functions of the large intestine?
23. How are the nonpathogenic bacteria in the large intestine beneficial?
24. What are three enzymes found in pancreatic juice, and what food does each digest?
25. Where is insulin produced?
26. What digestive juice is secreted by the liver?
27. What food does bile emulsify?
28. Briefly state five nondigestive functions of the liver.
29. What is the function of the gall bladder?
30. What is cholelithiasis?
31. What is the function of the peritoneum?
32. What is the greater omentum?

ANSWERS TO REVIEW QUESTIONS

1. to change insoluble food materials to a soluble form
2. a tube that extends from the mouth to the anus
3. pancreas and liver
4. (1) incisor—cutting, biting
   (2) canine—tearing, shredding
   (3) premolar—chewing, grinding
   (4) molar—chewing, grinding
5. (1) parotids—just below and in front of the ear
   (2) submandibular—in the angle of the lower jaw
   (3) sublingual—under the tongue
6. (1) guides food for chewing and swallowing
   (2) used in speech
   (3) contains taste buds
7. sweet, sour, salt, bitter
8. by a combination of the four tastes and by olfactory sense of the nose
9. to protect the alimentary and respiratory tracts from invasion by pathogenic bacteria
10. by peristalsis and gravity
11. pyloric and cardiac
12. folds in the inner layer of the stomach wall which unfold to make it possible for the stomach to distend as needed
13. (1) to receive swallowed food and pass it on to the small intestine
    (2) to secrete gastric juice
    (3) to churn food and mix it with gastric juice
    (4) to absorb water, alcohol, and some drugs
14. (1) duodenum—25 cm (10 inches)
    (2) jejunum—2.5 m (8 feet)
    (3) ileum—3.6 m (12 feet)
15. to complete digestion and to absorb digested food
16. (1) great length
    (2) villi
    (3) folds in the lining
17. in the capillary walls of the villi
18. (1) liver
    (2) pancreas
    (3) intestinal glands
19. cecum, appendix, ascending colon, transverse colon, descending colon, sigmoid colon, rectum
20. It is the first 3 inches of the large intestine which extends in a blind pouch from the juncture of the ileum and colon.
21. It extends from the lower portion of the cecal pouch.
22. (1) to remove water from intestinal contents
    (2) to secrete mucus
    (3) to eliminate feces
23. Some bacteria synthesize vitamin K and some of the B vitamins.
24. (1) amylopsin—starch to simple sugar
    (2) trypsin—protein to proteoses and polypeptides
    (3) lipase—fats to fatty acids
25. in the islands of Langerhans in the pancreas
26. bile

27. fats
28. (1) It destroys worn-out red blood cells and breaks down hemoglobin.
    (2) It manufactures heparin and plasma proteins.
    (3) It stores iron and copper, and vitamins A, D, E, and K.
    (4) It breaks down and detoxifies poisons that may be taken into the body. The liver stores some poisons.
    (5) It changes excess carbohydrate to glycogen or fat which is stored. It can transform the glycogen or fat into glucose in response to the body's need.
29. It stores bile.
30. the presence of gallstones
31. It secures and protects organs contained in the abdominal cavity.
32. a continuation of the serosa of the stomach and duodenum

Suggested Activity #1: Identification of Parts of the Digestive System UNIT 4

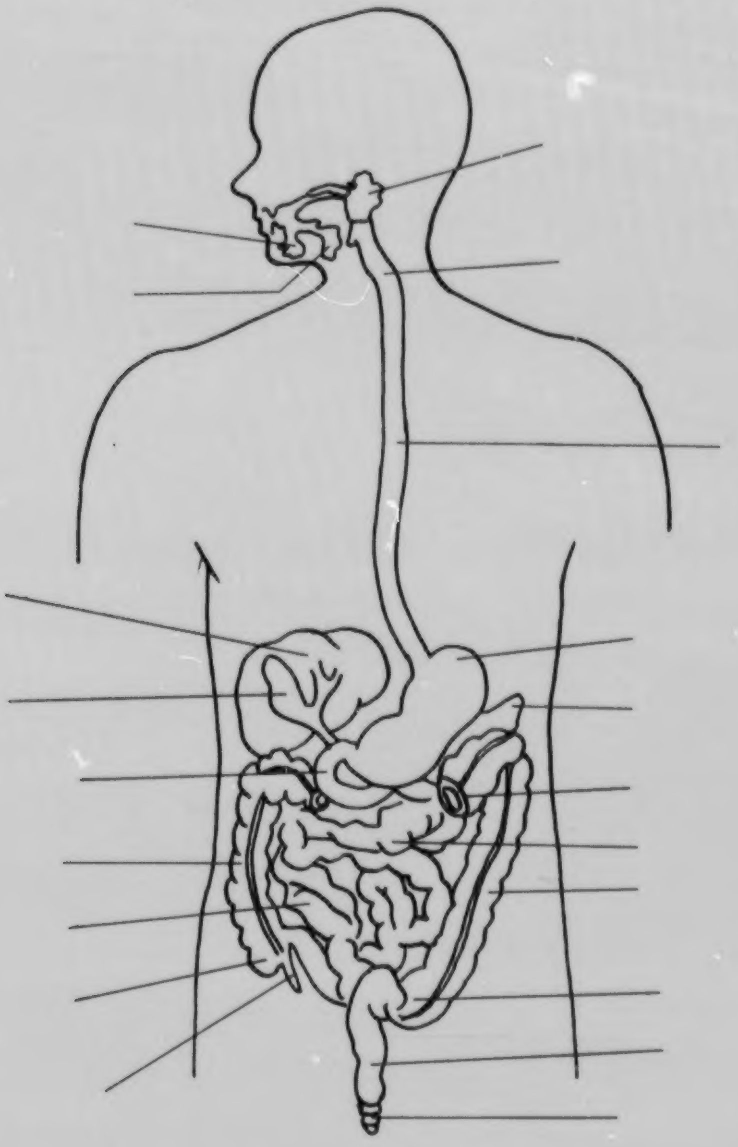
Objective: To identify parts of the digestive system

Materials: Diagram of the digestive system (fig. 4)
Torso model if available

Procedure:

1. Review the parts of the digestive tract shown in figure 4 in text.
2. If a model is available, identify the parts using the model.
3. Label the following parts of the digestive tract on the unlabeled diagram.

- salivary glands
  - sublingual
  - parotid
  - submandibular
- pharynx
- esophagus
- stomach
- liver
- pancreas
- gall bladder
- duodenum
- jejunum
- ileum
- appendix
- cecum
- ascending colon
- transverse colon
- descending colon
- sigmoid colon
- rectum
- anus



Suggested Activity #2: Word Find Puzzle

UNIT 4

Objective: To become familiar with terms used in studying the digestive system

Procedure: Search the puzzle for terms listed beneath the puzzle. They may be written forward, backward, vertically, horizontally, or diagonally. Circle each term as you find it.

P	E	R	I	T	O	N	I	T	I	S	T	H	R	O
A	Y	S	S	D	I	O	H	R	R	O	M	E	H	M
N	C	O	L	I	T	I	S	T	A	C	C	A	E	U
C	I	R	R	H	O	S	I	S	S	D	H	R	O	M
R	K	G	S	R	J	J	T	E	I	Y	O	T	H	P
E	C	A	I	W	H	A	I	I	T	S	L	B	O	S
A	O	S	T	A	E	E	T	R	I	E	E	U	L	I
T	N	T	I	E	R	C	A	A	T	N	C	R	E	T
I	S	R	V	H	N	I	P	C	A	T	Y	N	L	I
T	T	I	I	R	L	D	E	L	M	E	S	A	I	C
I	I	T	G	R	A	N	H	A	O	R	T	U	T	I
S	P	I	N	A	G	U	T	T	T	E	I	S	H	D
D	A	S	I	I	S	A	B	N	S	Y	T	E	I	N
D	T	H	G	D	E	J	H	E	R	N	I	A	A	E
R	I	C	R	E	C	L	U	D	W	Z	S	L	S	P
V	O	M	I	T	I	N	G	A	N	D	E	F	I	P
A	N	O	R	E	X	I	A	N	E	R	V	O	S	A

anorexia nervosa
appendicitis
cholecystitis
cholelithiasis
cirrhosis
colitis

constipation
dental caries
diarrhea
dysentery
gastritis
gingivitis

heartburn
hemorrhoids
hepatitis
hernia
jaundice
mumps

nausea
pancreatitis
peritonitis
pyorrhea
stomatitis
ulcer
vomiting

Suggested Activity #3: Demonstration of Swallowing (Deglutition)

Objective: To observe the process of swallowing

Materials: Glass of water
Stethoscope

Procedure: Students may work in pairs or individually.

1. Drink several sips of water. Note the movement of your tongue.
2. Place your fingers on either side of the larynx. Take several sips of water. Note the movement of your larynx.
3. Try to keep the larynx from moving as you try to swallow.
4. Place the stethoscope over the point where the esophagus enters the stomach (the lower end of the sternum). Take several large swallows of water. Can you hear the water enter the stomach?

Results:

1. Describe the movement of the tongue as you swallowed the water.
2. Describe the movement of the larynx as you swallowed.
3. Could you swallow without moving the larynx?
4. Could you hear the water from the esophagus enter your stomach?
5. What is the name of the end of the stomach which receives water from the esophagus?

Objective: To identify digestive juices and enzymes and their action

Materials: Chart of Digestive Juices and Enzymes

Procedure: Place the correct information in the numbered spaces on the chart.

DIGESTIVE JUICES AND ENZYMES

Digestive juices and enzymes	Source	Place of Action	Action of enzyme or digestive juice
Saliva		Mouth	
Ptyalin (amylase)	(1) ____________		Begins starch digestion
Gastric juice	Stomach		
Pepsin (protease)		(2) ____________	Begins protein digestion
(3) ____________			Curdles milk
(4) ____________			Kills some pathogenic bacteria Activates gastric enzymes
Bile (contains no enzymes)	Liver	Small intestine	(5) ____________
Pancreatic juice	Pancreas	Small intestine	
(6) ____________			Acts on protein
Amylase			(7) ____________
Lipase			Acts on fats
Intestinal juice	Small intestine	Small intestine	
(8) ____________			Acts on protein
Sucrase			Changes sucrose to simple sugar
Lactase			(9) ____________
(10) ____________			Changes maltose to simple sugar

Suggested Activity #5: Chemical Digestion

Objective: To demonstrate digestion of starch

Materials:
Starch suspension
Lugol's solution
Benedict's solution

Procedure:

1. Suspend 1 teaspoon of starch in about 100 ml of distilled water.
2. Place 5 ml of starch suspension in test tube.
3. Add a drop of Lugol's solution. Notice color change.
4. Place 10 ml of starch suspension in a test tube. Add two drops of saliva.
5. Place in water bath (or incubator) at 37°-40°C until the solution becomes colorless (about ½ hour).
6. Place 5 ml of Benedict's solution in a test tube.
7. Add 4 drops of colorless solution from step 5. Place in boiling water bath for two minutes. Note any color change. If glucose is present, there will be a green, yellow to red color with orange precipitate.

Results:

1. What color change did you observe when Lugol's solution was added to starch?
2. Why did the starch suspension become colorless?
3. Explain the presence of glucose in step 6 of the procedure.

Lugol's Solution

1 g iodine crystals
2 g potassium iodide
300 ml distilled water
A deep blue-black color results in the presence of starch

Benedict's Solution

Copper sulfate	17.3 gm
Sodium citrate	173 gm
Sodium carbonate (anhydrous)	100 gm
Distilled water to make	1000 ml

Suggested Activity #6: Taste Perception

Objective: To determine the location and function of taste buds

Materials: Blindfold, droppers, swabs
Assorted foods:
sucrose, 10% solution
table salt, 10% solution (sodium chloride)
quinine sulfate, 1% solution (magnesium sulfate)
lemon juice
raw pear sections
raw potato
raw onion
mild cheese
strong (sharp) cheese

Procedure: This may be done as a demonstration, or students may work in pairs. In any case, the student who is to be "tested" must not see the various foods used. Using a cotton swab—

1. Brush the tip, back, and sides of the tongue with each of the following: sucrose, salt, quinine sulfate (or epsom salts). Use a fresh swab for each one. Rinse the mouth with water after each solution is used.

2. Note area of the tongue where each solution was detected.

3. Check your results with the areas listed in the text.

Now, blindfold the demonstrator, and ask him/her to hold the nostrils closed. Be sure the pieces of food to be tested are the same size. Place each of the following foods on the tongue in quick succession. Ask the person being tested to identify each food. Then determine the accuracy with which the demonstrator could identify foods by taste alone.

Results:

1. What are the four tastes that can be detected by taste buds?

2. Make a rough sketch, indicating the area of the tongue where each taste can be identified.

3. How accurately could you (your partner) identify taste without other senses?

4. If your doctor prescribed a bitter tablet, how could you swallow it with minimum bitter taste?

Suggested Activity #7: Demonstration of the Length of the Digestive Tract

Objective: To observe the length of and relative position of parts of the digestive tract

Procedure: This activity should be done as a demonstration. A small group of students could prepare the "model" and demonstrate it to other class members.

1. Obtain a piece of soft garden hose, rubber tubing, tape, or rope that is about 20 feet long. Stretch it out from end to end.
2. Attach models or paper labels in the relative position of various parts—for example, stomach, liver, pancreas, appendix.
3. Label the various divisions of the digestive tract, such as duodenum, ileum, and so on.
4. Then, as the class observes, arrange the digestive tract so that it could fit into the abdominal cavity.

Results: This project should improve the students' concept of the length of the digestive tract and of the relative positions of the parts.

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper. Suggested topics are:

- The Mechanics of Speech
- Biochemical Changes in Foods in Digestion
- Investigation of Any Specific Disease of the Digestive Tract
- Current Trends in Weight Control
- OTC Drugs for Digestive Disturbances

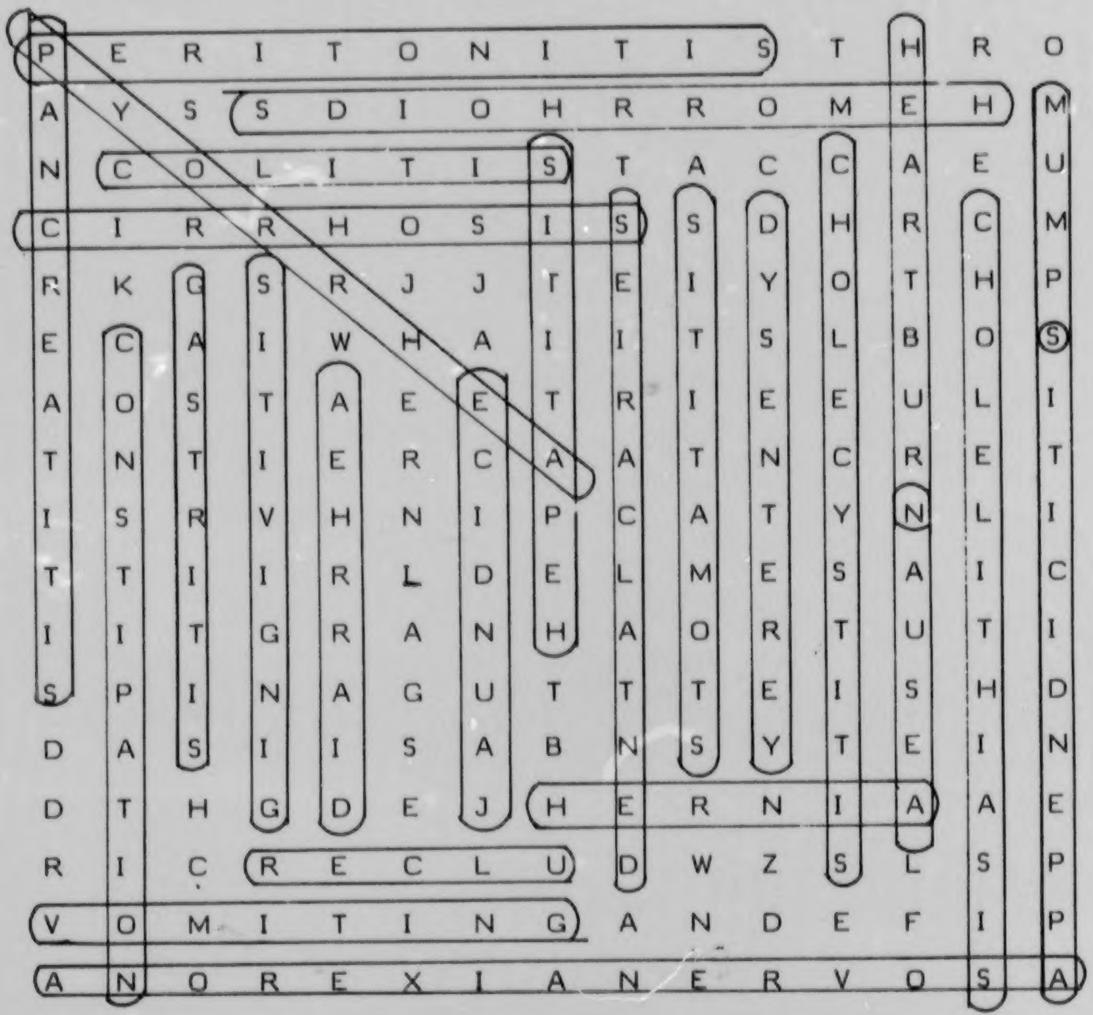
Topics should reflect individual student interest. Often the topic can provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Identification of Parts of the Digestive System

1. parotid gland
2. sublingual gland
3. submandibular gland
4. pharynx
5. esophagus
6. stomach
7. pancreas
8. duodenum
9. transverse colon
10. jejunum
11. descending colon
12. sigmoid colon
13. rectum
14. anus
15. appendix
16. cecum
17. ileum
18. ascending colon
19. gall bladder
20. liver

Suggested Activity #2: Word Find Puzzle



P	E	R	I	T	O	N	I	T	I	S	T	H	R	O
A	Y	S	S	D	I	O	H	R	R	O	M	E	H	M
N	C	O	L	I	T	I	S	T	A	C	C	A	E	U
C	I	R	R	H	O	S	I	S	S	D	H	R	C	M
R	K	G	S	R	J	J	T	E	I	Y	O	T	H	P
E	C	A	I	W	H	A	I	I	T	S	L	B	O	S
A	O	S	T	A	E	E	T	R	I	E	E	U	L	I
T	N	T	I	E	R	C	A	A	T	N	C	R	E	T
I	S	R	V	H	N	I	P	C	A	T	Y	N	L	I
T	T	I	I	R	L	D	E	L	M	E	S	A	I	C
I	I	T	G	R	A	N	H	A	O	R	T	U	T	I
S	P	I	N	A	G	U	T	T	T	E	I	S	H	D
D	A	S	I	I	S	A	B	N	S	Y	T	E	I	N
D	T	H	G	D	E	J	H	E	R	N	I	A	A	E
R	I	C	R	E	C	L	U	D	W	Z	S	L	S	P
V	O	M	I	T	I	N	G	A	N	D	E	F	I	P
A	N	O	R	E	X	I	A	N	E	R	V	O	S	A

Suggested Activity #3: Demonstration of Swallowing (Deglutition)

1. The tongue moves upward to the roof of the mouth, then backward.
2. The larynx moves upward, then down, as one swallows.
3. no
4. yes
5. cardiac

Suggested Activity #4: Identification of Digestive Juices and Enzymes

1. salivary glands
2. stomach
3. rennin (in children)
4. hydrochloric acid
5. emulsifies fats
6. trypsin
7. acts on starch
8. acts on protein
9. changes lactose to simple sugar
10. maltase

Suggested Activity #5: Chemical Digestion

1. The starch suspension turned blue-black in the presence of iodine solution.
2. The starch suspension became colorless because the enzymes in saliva brought about the digestion of starch to simple sugar.
3. Glucose is found in the solution in step 6 because starch was digested to form glucose.

Suggested Activity #6: Taste Perception

1. sweet, sour, salt, bitter
2. bitter at back of tongue
   sweet on tip of tongue
   sour on each side of tongue
   salt on each side but nearer the tip of the tongue
3. Answers will vary, but should imply that only sweet, sour, salt, and bitter are tasted by the tongue.
4. Avoid contact with the back of the tongue; keep medication dry.

Suggested Activity #7: Demonstration of the Length of the Digestive Tract

Performed to the satisfaction of the instructor.

Suggested Activity #8: Research Paper

The paper should be evaluated to the satisfaction of the instructor.

TEST / UNIT 4

The Digestive System

I. Match the following terms with the definitions using letter answers.

_____ 1. the changing of insoluble foods to a soluble form by the action of enzymes

_____ 2. the wavelike motion of the muscle tissue of the alimentary canal that moves food through the digestive tube

_____ 3. a circular muscle that constricts an opening

_____ 4. compound produced in the liver which prevents blood from clotting

_____ 5. protein substances produced in cells that bring about chemical reactions in digestion

_____ 6. short, hairlike projections from the walls of the small intestine through which digested food is absorbed

_____ 7. the act of swallowing

_____ 8. to break into small particles

_____ 9. the material formed by the mixing and partial digestion of food in the stomach

_____ 10. body wastes; the residue of digestion discharged from the anus

_____ 11. an intestinal lymph vessel

_____ 12. the continuous tube that extends from the mouth to the anus; the process of digestion takes place here

a. alimentary canal
b. chyme
c. deglutition
d. digestion
e. emulsify
f. enzyme
g. feces
h. heparin
i. lacteal
j. peristalsis
k. sphincter
l. villi

II. Label the indicated parts of the diagram of the digestive system.

1. ______ 11. ______

2. ______ 12. ______

3. ______ 13. ______

4. ______ 14. ______

5. ______ 15. ______

6. ______ 16. ______

7. ______ 17. ______

8. ______ 18. ______

9. ______ 19. ______

10. ______ 20. ______

III. The accompanying chart of "Digestive Juices and Enzymes" is incomplete. Write the appropriate term in the numbered spaces below. Please do not write on the diagram.

1. ______

2. ______

3. ______

4. ______

5. ______

6. ______

7. ______

8. ______

9. ______

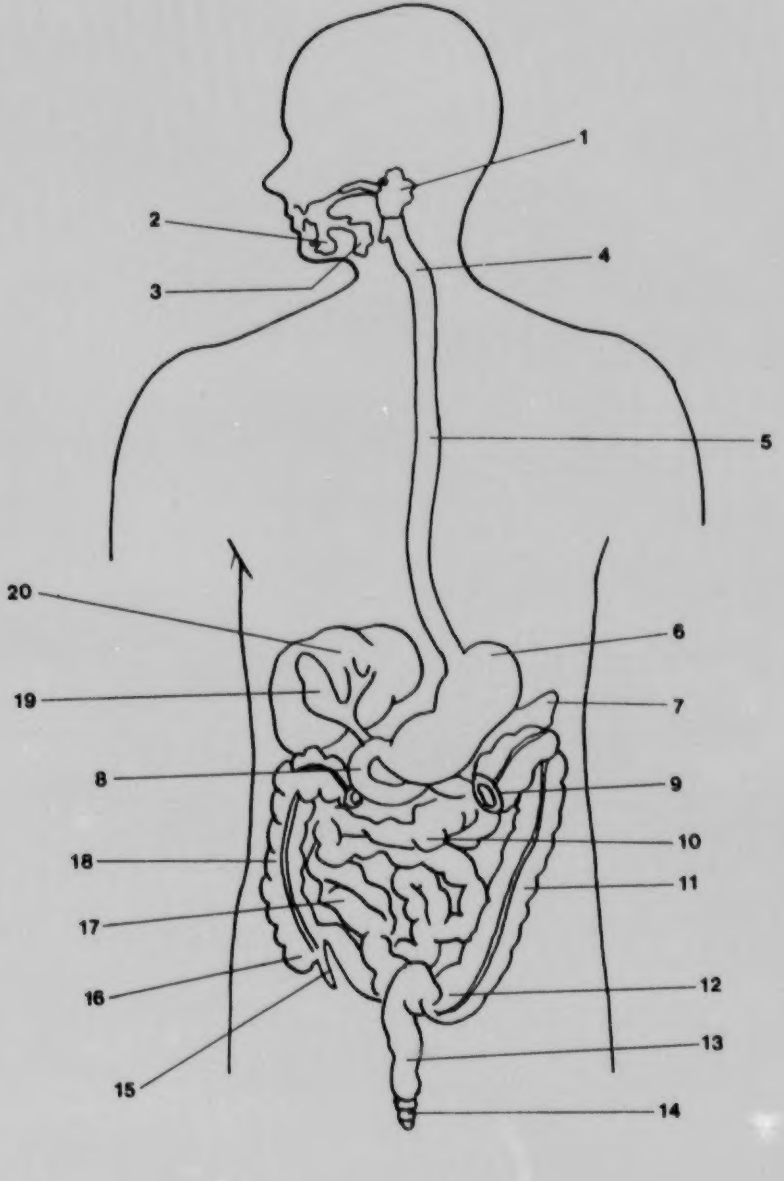
10. ______

IV. Complete the following statements.

1. Four kinds of teeth are molars, incisors, premolars, and ______ 1.

2. The changing of insoluble food into a soluble form by the action of enzymes is ______ 2.

3. The function of the tonsils is to protect the alimentary and respiratory tracts from invasion by ______ 3.



DIGESTIVE JUICES AND ENZYMES

Digestive juices and enzymes	Source	Place of Action	Action of enzyme or digestive juice
Saliva		Mouth	
Ptyalin (amylase)	(1) ____________________		Begins starch digestion
Gastric juice	Stomach	(2) ________________	
Pepsin (protease)			Begins protein digestion
(3) ______________			Curdles milk
(4) ______________			Kills some pathogenic bacteria Activates gastric enzymes
Bile (contains no enzymes)	Liver	Small intestine	(5) _________________
Pancreatic juice	Pancreas	Small intestine	
(6) ________________			Acts on protein
Amylase			(7) __________________
Lipase			Acts on fats
Intestinal juice	Small intestine	Small intestine	
(8) _________________			Acts on protein
Sucrase			Changes sucrose to simple sugar
Lactase			(9) ___________________________
(10) ________________			Changes maltose to simple sugar

4. Food is moved through the esophagus by gravity and __________ 4.

5. The function of the large intestine is to secrete mucus, eliminate feces, synthesize vitamins, and __________ 5.

6. The islands of Langerhans in the pancreas secrete __________, which is required for the metabolism of sugar. __________ 6.

7. The gall bladder stores __________ 7.

8. The continuation of the serosa of the stomach and duodenum that is suspended like a curtain over the intestines is the __________ 8.

9. A circular muscle that constricts an opening is a __________ 9.

10. Digested food enters the bloodstream from the villi by active transport and __________ 10.

V. Give three basic functions of the stomach:

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

VI. Give three ways in which the surface area of the small intestine is increased.

1. ______________________________

2. ______________________________

3. ______________________________

VII. List three nondigestive functions of the liver:

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

VIII. The following are descriptions of diseases of the digestive tract. Write the correct disease from the four choices offered in each question.

1. tooth decay
(dental caries, nausea, cirrhosis, pyorrhea) ______________ 1.

2. inflammation of the lining of the mouth
(gingivitis, stomatitis, mumps, hepatitis) ______________ 2.

3. abnormally frequent, watery bowel movements
(dysentery, diarrhea, vomiting, nausea) ______________ 3.

4. feeling of illness, unpleasant sensation usually preceding vomiting
(peritonitis, gastritis, heartburn, nausea) ______________ 4.

5. inflammation of the gall bladder
(cholecystitis, cholelithiasis, jaundice, cirrhosis) ______________ 5.

6. abnormal delay in or infrequent bowel movements
(hemorrhoids, gastric ulcer, colitis, constipation) ______________ 6.

7. loss of appetite without evidence of disease; thought to be a type of mental illness
(anorexia nervosa, ulcer, vomiting, appendicitis) ______________ 7.

8. inflammation of the liver
(jaundice, pancreatitis, colitis, hepatitis) ______________ 8.

9. open lesion of the mucous membrane of the intestinal tract with sloughing of tissue and inflammation
(ulcer, hernia, hemorrhoid, stomatitis) ______________ 9.

10. reverse peristalsis resulting in ejection of stomach contents through the mouth
(nausea, constipation, anorexia nervosa, vomiting) ______________ 10.

ANSWERS TO TEST

I.
1. d
2. j
3. k
4. h
5. f
6. l
7. c
8. e
9. b
10. g
11. i
12. a

II.
1. parotid (salivary glands)
2. sublingual (salivary glands)
3. submandibular (salivary glands)
4. pharynx
5. esophagus
6. stomach
7. pancreas
8. duodenum
9. transverse colon
10. jejunum
11. descending colon
12. sigmoid colon
13. rectum
14. anus
15. appendix
16. cecum
17. ileum
18. ascending colon
19. gall bladder
20. liver

III.
1. salivary glands
2. stomach
3. rennin (in children)
4. hydrochloric acid
5. emulsifies fats
6. trypsin
7. acts on starch
8. acts on protein
9. changes lactose to simple sugar
10. maltase

IV.
1. canine
2. digestion
3. bacteria
4. peristalsis
5. absorb water
6. insulin
7. bile
8. greater omentum
9. sphincter
10. diffusion

V. Any three of these:
1. receives swallowed food from the esophagus and passes it on to the small intestine
2. secretes gastric juice containing digestive enzymes and hydrochloric acid
3. churns food and gastric juice to begin digestion
4. absorbs water, ethyl alcohol, and some drugs

VI.
1. villi
2. permanent folds in the lining
3. great length

VII. Any three of these:

1. destroys red blood cells and breaks down hemoglobin
2. manufactures heparin and other proteins found in blood plasma such as prothrombin, fibrinogen, and albumin
3. stores vitamins A, D, E, and K, as well as copper and iron
4. contains enzymes that break down and destroy poisons; stores poisons that cannot be destroyed, such as DDT
5. changes excess carbohydrate into glycogen or fat which can be stored, then changes it back into glucose in response to body needs

VIII.

1. dental caries
2. stomatitis
3. diarrhea
4. nausea
5. cholecystitis
6. constipation
7. anorexia nervosa
8. hepatitis
9. ulcer
10. vomiting

Unit 5

The Blood and Cardiovascular System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the cardiovascular system;
2. discuss the functions of blood;
3. describe and give the function of the formed elements of blood;
4. give the role of platelets in the coagulation of blood;
5. discuss the significance of ABO blood types;
6. tell why the Rh factor is important in some pregnancies and transfusion;
7. describe the structure of the heart;
8. trace the course of the blood through the heart;
9. discuss the conduction system of the heart;
10. define pulse and blood pressure;
11. name the types of blood vessels;
12. describe the two major circuits formed by the blood vessels;
13. name and give the function of the components of the lymph system; and
14. identify common diseases of the blood and cardiovascular system.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Microscopic Examination of the Blood"

Students will achieve a more accurate concept of the actual size and shape of blood cells when they study real cells. This activity is made easier by using commercially prepared slides, but the dramatic impact of looking at one's own blood may be desirable.

Suggested Activity #3: "Determining ABO and Rh Blood Types"

Most students are very interested in determining their own blood type. It is wise to explain that discrepancies may occur in this setting, however. The exercise using known types of blood should be done first.

Suggested Activity #4: "Identification of the Parts of the Heart and the Course of Blood Through the Heart"

This exercise should familiarize the student with the actual structure of the heart and improve his/her concept of the work of the heart. The demonstration of the calf heart shows the structure and size dramatically.

Suggested Activity #5: "Identification of Diseases"

This exercise provides practice in recognition of the correct terms to match definitions. Reading the definitions for identification reinforces recognition.

Suggested Activity #6: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 5

Review Questions

1. Explain why blood is considered to be a type of connective tissue.
2. What are the three main functions of blood?
3. What is blood plasma?
4. Name and identify three plasma proteins.
5. What are six other soluble components of plasma?
6. Where are red blood cells produced?
7. What is their shape and size?
8. What are the two parts of the hemoglobin molecule?
9. What is the function of iron contained in the hemoglobin molecule?
10. What becomes of worn-out and disintegrated red blood cells?
11. What becomes of the iron atoms released from disintegrated red blood cells?
12. What is the function of red blood cells?
13. Name three kinds of granulocytes.
14. Where are granulocytes and agranulocytes formed?
15. Give a specific function of each of these kinds of leukocytes:
    a. neutrophiles
    b. eosinophiles
    c. basophiles
    d. lymphocytes
    e. monocytes
16. What is a differential white blood cell count?
17. What is the function of platelets?
18. How do antithrombins prevent clotting of the blood?
19. Define **antigen** and **antibody**.
20. Name the two agglutinogens found on the surface of human red blood cells.
21. Why is blood group O called the universal donor?
22. Name two situations in which the Rh factor is important to Rh negative individuals.
23. Why is a second pregnancy of an Rh-negative mother with a second Rh-positive fetus possibly dangerous to the fetus?
24. Describe where the heart is located.
25. Name and locate the three layers of the heart.
26. Name and locate the three structures that make up the conduction system of the heart.
27. What is an electrocardiogram?
28. What part of the nervous system controls heart activity?
29. What is the pulse?
30. What are five factors that influence pulse rate?
31. What is blood pressure?
32. Differentiate between **systole** and **diastole.**
33. Which vessels return blood to the heart? away from the heart? (except pulmonary vessels)
34. Why is the circulatory system called a closed system?
35. What causes the blood to flow through the arteries? through the veins?
36. What are the two major circuits formed by the blood vessels?
37. What blood vessels carry the blood in the pulmonary circuit?
38. Why is the lymph system considered a part of the circulatory system?
39. Name the components of the lymph system.
40. What is **lymph**?
41. Name the vessels of the lymphatic system.

42. Name the blood vessels into which the right lymphatic duct and the thoracic duct empty.
43. What is a lymph node?
44. What is the function of lymph nodes?
45. Name three lymphatic organs.
46. What are lacteals?

ANSWERS TO REVIEW QUESTIONS

1. The liquid plasma is the matrix, while the blood cells are the formed elements.
2. (1) transportation
   (2) regulates and equalizes body temperature by distributing heat to body parts
   (3) defends body against disease
3. Plasma is the liquid part of blood that has been prevented from clotting by the addition of an anticoagulant.
4. (1) albumins—maintain blood viscosity
   (2) globulins—antibodies produced by leukocytes
   (3) fibrinogen—necessary for clot formation
5. (1) nutrients—such as glucose, lipids, and amino acids
   (2) organic wastes—urea, uric acid, ammonia salts, and creatine
   (3) inorganic salts
   (4) oxygen
   (5) carbon dioxide
   (6) regulatory substances—enzymes and hormones
6. in the red marrow of bones
7. biconcave disc; 7 to 7.5 microns in diameter
8. (1) globin, a protein molecule
   (2) heme, a pigment
9. Iron combines with oxygen.
10. Pieces are engulfed and destroyed by the reticuloendothelial cells of the liver and spleen.
11. Iron is stored in the liver until it is transported to the bone marrow to be used in building more red blood cells.
12. transportation of oxygen and carbon dioxide
13. neutrophiles, eosinophiles, basophiles
14. granulocytes—in the red bone marrow
    agranulocytes—in lymphoid tissue and bone marrow
15. a. neutrophiles—phagocytosis of microorganisms produces lysozyme which destroys some bacteria
    b. eosinophiles—detoxify proteins that accumulate in allergic reactions; destroy cellular debris from parasitic infestations
    c. basophiles—contain heparin which prevents coagulation of blood in vessels; facilitates clot absorption
    d. lymphocytes—production of antibodies and immune responses
    e. monocytes—phagocytize microorganisms and cellular debris following infection
16. a determination of the percentage of each kind of leukocyte
17. vital to coagulation of blood
18. Antithrombins inactivate thrombin, thus inhibiting the conversion of fibrinogen to fibrin.
19. **antigen**—a substance that stimulates the body to produce antibodies
    antibody—protein substance in blood plasma developed in response to an antigen and reacting specifically with that antigen
20. A and B
21. There are no antigens on the red blood cells, and theoretically the blood would not react with any cells in transfusion.
22. (1) pregnancy
    (2) blood transfusion
23. The mother may have Rh antibodies as a result of stimulation by the first Rh-positive pregnancy. These antibodies may react with Rh antigens on the blood cells of the fetus, causing them to hemolyze and release hemoglobin.

24. It is located in the chest cavity. The top is at a point between the second and third ribs. The apex is between the fifth and sixth ribs.
25. (1) outer layer—epicardium
    (2) middle layer—myocardium
    (3) inner layer—endocardium
26. (1) sinoatrial node—upper wall of right atrium
    (2) atrioventricular node—lower part of right atrial wall
    (3) atrioventricular bundle—goes down each side of the septum dividing the right and left ventricles
27. a record of the electrical activity of the heart
28. the autonomic nervous system
29. waves of increased pressure in arteries as a result of ventricular contraction or the alternate expansion and recoil of an artery
30. (1) body size
    (2) muscular activity
    (3) emotional disturbance
    (4) infections
    (5) endocrine secretions
31. the pressure blood exerts on the inside of the walls of the blood vessels
32. **Systole** is the pressure on blood vessels during the contraction of the heart muscles. **Diastole** is the pressure on blood vessels that occurs during the relaxation of heart muscle.
33. Veins return blood to the heart. Arteries carry blood away from the heart.
34. The vessels and heart are all connected. The heart pumps the blood through the arteries, then to the arterioles to the capillaries, next to the venules, then to veins, and back to the heart.
35. arteries—the force of the heartbeat
    veins—valves in inner lining of veins prevent backflow of blood
36. (1) pulmonary
    (2) systemic
37. pulmonary arteries and pulmonary veins
38. It aids in returning tissue fluid to the blood vessels.
39. lymphatic capillaries, two large lymph ducts, lymph organs, lymph nodes, and lymph
40. the clear, watery fluid found in the lymphatic vessels
41. lymph capillaries, lymphatic veins, lymphatic ducts
42. The right lymphatic duct empties into the right subclavian vein. The thoracic duct empties into the left subclavian vein.
43. small rounded masses of lymphoid tissue scattered all over the body along the course of lymphatic vessels
44. Phagocytes in lymph nodes destroy microorganisms and cellular debris; produces lymphocytes.
45. tonsils, thymus, spleen
46. lymphatic capillaries in the villi of the small intestine that collect digested fat from the digestive tract

Suggested Activity #1: Practice with New Terms

Match the following terms with the phrases using letter answers.

_____ 1. liquid portion of coagulated blood

_____ 2. pertaining to mitosis or cell division

_____ 3. any substance that stimulates the body to produce antibodies

_____ 4. the study of blood

_____ 5. cell which engulfs and destroys bacteria and cellular debris

_____ 6. clumping together of small particles

_____ 7. small, rounded mass of tissue; a protuberance or swelling

_____ 8. blood clot

_____ 9. blood clot that has dislodged from its place of origin

_____ 10. copious bleeding, undue loss of blood

_____ 11. term for cells scattered throughout the body; such as the liver, spleen, tonsils, lymph nodes and others, that ingest foreign particles

_____ 12. intercellular material of a tissue

_____ 13. substance which prevents the coagulation of blood

_____ 14. liquid part of the blood that has been prevented from clotting by the addition of an anticoagulant

_____ 15. movement of leukocytes through the unbroken capillary wall

_____ 16. process of clotting

_____ 17. recording of the electrical activity of the heart

_____ 18. protein substance in blood serum developed in response to an antigen and reacting specifically with that antigen

_____ 19. clear, watery fluid found in lymphatic vessels

_____ 20. mechanism by which blood clots are dissolved

a. agglutination

b. antibody

c. anticoagulant

d. antigen

e. coagulation

f. diapedesis

g. electrocardiogram

h. embolus

i. fibrinolysis

j. hematology

k. hemorrhage

l. lymph

m. matrix

n. megakaryocyte

o. mitotic

p. node

q. phagocyte

r. plasma

s. reticuloendothelial

t. serum

u. thrombus

Suggested Activity #2: Microscopic Examination of Blood

Objective: To learn to differentiate among kinds of blood cells*

Materials:

Cotton
70% alcohol
Glass slides
Staining rack
Wright's Stain
Distilled water
Needle (lancet)
Microscope

Procedure:

1. Wash hands with soap and water; dry.
2. Cleanse middle finger with 70% ethyl alcohol.
3. Puncture fingertip with sterile needle.
4. Touch glass slide to drop of blood on finger.
5. Take second glass slide, and place at a 45° angle on first slide.
6. Let blood run in thin line across junction of two slides.
7. Push second slide up the length of first slide to spread blood (see fig. 1).
8. Allow smear to dry in air.
9. Flood smear with Wright's Stain.
10. Allow stain to remain one minute.
11. Add neutral distilled water (or Wright's buffer if available).
12. Allow slide to stand for 3 to 6 minutes until metallic sheen appears.
13. Rinse thoroughly with distilled water.
14. Allow slide to dry.
15. Study stained slide under high power of the microscope.
16. Move the slide around until you have seen red blood cells, the different kinds of white blood cells, and platelets.
17. Study the cells using the oil-immersion objective if your microscope has one.
18. Sketch the different kinds of cells you observe.

Results:

1. What color were the stained red blood cells?
2. Why are red blood cells lighter in color in the center?
3. Why is unstained blood red?
4. What is the function of hemoglobin?
5. How many different kinds of white blood cells did you identify?
6. How do white blood cells differ in appearance from red blood cells?
7. Describe platelets.
8. What is the function of platelets?

*Commercially prepared slides of stained human blood may be used.

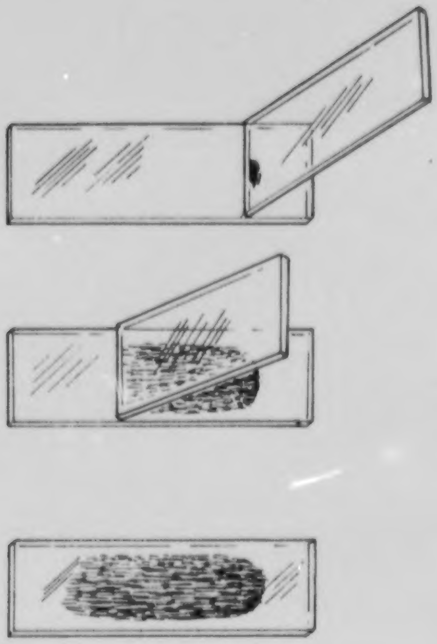


Fig. 1. Preparing blood smear

	ANTI-A SERUM	ANTI-B SERUM	BLOOD TYPE
AGGLUTINATION WITH ANTI-A ONLY	+	−	A
AGGLUTINATION WITH ANTI-B ONLY	−	+	B
AGGLUTINATION WITH BOTH ANTI-A and ANTI-B	+	+	AB
NO AGGLUTINATION	−	−	O

Fig. 2. ABO blood typing

Suggested Activity #3: Determining ABO and Rh Blood Types UNIT 5

Objectives: To learn the procedure for blood type determinations
To explain the reactions in blood typing procedures

Materials: Tubes of red blood cells of Types A, B, AB, and O and Rh negative and Rh positive
Glass slides
Wax pencils
Toothpicks
Anti-B serum
Anti-A serum
Anti-Rho typing serum

Students may wish to determine their own A, B, O and Rh blood type. If so they will need to follow the procedure in Suggested Activity #2 for obtaining blood from a fingertip.

Procedure:

1. Divide a glass slide in half with a wax pencil.
2. Label the left side Anti-A, and the right side Anti-B.
3. Place one drop of Anti-A serum on the left side.
4. Place one drop of Anti-B serum on the right.
5. Place one drop of blood on each side.
6. Mix each side containing serum and blood cells with a toothpick.
7. Use a different toothpick for each side.
8. Look for agglutination of cells.
9. Refer to figure 2 to determine the type of blood tested.
10. Now take the second slide, and draw a ring in the center of the slide with the wax pencil.
11. Place one drop of Anti-Rho typing serum in the center of the ring.
12. Add a large drop of blood.
13. Using a clean toothpick, stir to mix thoroughly.
14. After two minutes, look for agglutination of red blood cells.

Results: What is the blood type in the following reactions?

1. Red blood cells agglutinated with both Anti-A and Anti-B serum.
2. Red blood cells agglutinated with Anti-A serum only.
3. Red blood cells did not agglutinate with either Anti-A or Anti-B serum.
4. Red blood cells agglutinated with Anti-B serum only.
5. What is the Rh determination if red blood cells agglutinated in the presence of Rho serum?
6. Explain why Type O is called the "universal donor."

Suggested Activity #4: Identification of Parts of the Heart and the Course of the Blood Through the Heart

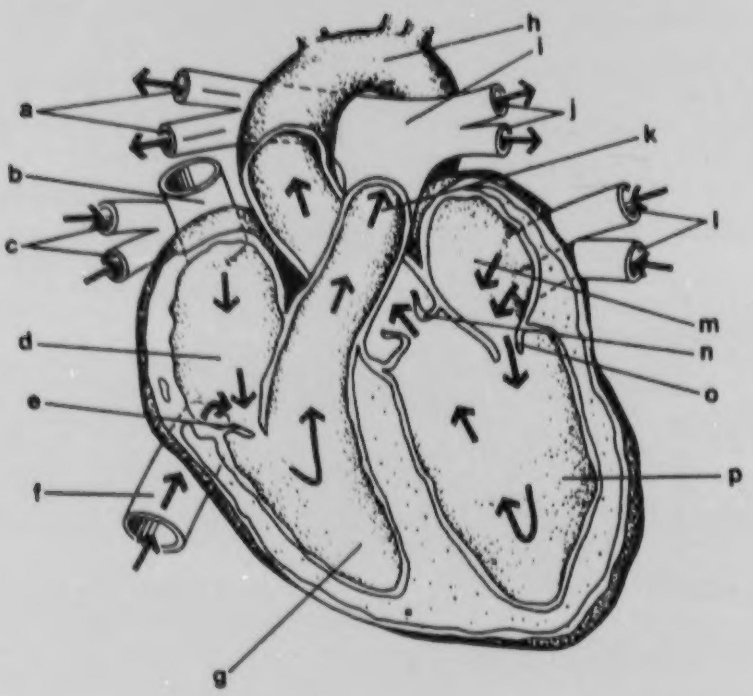
Objectives: To identify the parts of the heart
To trace the course of the blood through the heart

Materials: Diagrams of dissected heart
Model of heart if available
Dissected sheep (calf) heart if available

Procedure:
1. Review the names of the chambers and valves of the heart from figure 8.
2. Identify the parts of the heart using the model.
3. Identify the parts of the dissected animal heart.

Results:
1. Label the parts on the diagram of the heart.
2. Answer the following questions about the flow of the blood through the heart.
   a. In which organ does hemoglobin combine with oxygen?
   b. What are the lower chambers of the heart called?
   c. Which side of the heart receives blood poor in oxygen?
   d. Why are valves needed in the heart?
   e. What is the pericardium?
   f. What is the heart muscle called?
3. Trace the course of the blood through the heart by writing in the name of the appropriate valve or chamber.

The blood returns to the heart by means of the superior and inferior vena cava. It enters the (a) ______________________________, passes through the (b) ______________________________ valve to the (c) ______________________________. It flows through the (d) ______________________________ valve, thence through the pulmonary arteries to the lungs where the blood loses carbon dioxide and gets a supply of oxygen. The oxygenated blood returns to the heart by means of the pulmonary vein, enters the (e) ______________________________ of the heart. Then it flows through the (f) ______________________________ valve to the (g) ______________________________. Finally, the blood passes through the (h) ______________________________ valve to the aorta and thence to the body.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Suggested Activity #5: Identification of Diseases UNIT 5

Objective: To identify common diseases of the blood and cardiovascular system

Procedure: Write the correct disease for each of the following descriptions. The diseases described are listed below.

anemia
aneurysm
angina pectoris
arteriosclerosis
atherosclerosis
coronary occlusion
erythroblastosis fetalis
hemophilia
hemorrhage
infectious mononucleosis
ischemia
leukemia
murmur
varicose veins

1. disease of the newborn in which red blood cells hemolyze as a result of the presence of incompatible Rh antibody in the mother's blood ______________ 1.
2. copious bleeding; undue loss of blood ______________ 2.
3. deficiency in the number of erythrocytes or reduced hemoglobin ______________ 3.
4. an accumulation of fats and other substances in the arteries ______________ 4.
5. closing off of a coronary artery ______________ 5.
6. an abnormal dilatation of blood vessels ______________ 6.
7. severe chest pain caused by an insufficient flow of blood to the heart ______________ 7.
8. insufficient blood supply to a given part of the body ______________ 8.
9. acute infectious disease characterized by enlargement and tenderness of lymph nodes, increase in atypical monocytes, fever, sore throat, and general malaise ______________ 9.
10. abnormal heart sound ______________ 10.

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper. Suggested topics are:

- Modern Miracle Workers—Heart Surgeons
- Problems Encountered in Transfusions of Whole Blood and Plasma
- Inheritance of Blood Factors
- Heart Disease and Diet

Topics should reflect student interest. The topic could provide the student with information regarding a specific career.

Results: The paper should be evaluated to the satisfaction of the instructor.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. t
2. o
3. d
4. j
5. q
6. a
7. p
8. u
9. h
10. k
11. s
12. m
13. c
14. r
15. f
16. e
17. g
18. b
19. l
20. i

Suggested Activity #2: Microscopic Examination of Blood

1. pale pink
2. because they are biconcave disk-shaped, and thus thinner in the middle
3. It contains red pigment, hemoglobin.
4. It combines with and transports oxygen.
5. Answers will vary.
6. White blood cells are larger, nucleated, and stain either purple or red. Red blood cells are smaller, nonnucleated, and stain pink.
7. They are small, irregularly shaped, and stain purple.
8. clotting of blood

Note: It is suggested that students have an opportunity to observe the procedure for erythrocyte and leukocyte counts using diluting pipettes and a hemocytomer. It could be done as a demonstration, class project, or observed in a hospital or clinic.

Suggested Activity #3: Determining ABO and Rh Blood Types

1. AB
2. A
3. O
4. B
5. Rh positive
6. Persons with Type O blood have no antigens on their red blood cells, and therefore should not cause the red blood cells of any patient to agglutinate.

Suggested Activity #4: Identification of Parts of the Heart and the Course of the Blood Through the Heart

1. a. right pulmonary artery
   b. superior vena cava
   c. right pulmonary veins
   d. right atrium
   e. tricuspid valve
   f. inferior vena cava
   g. right ventricle
   h. aortic arch
   i. pulmonary artery
   j. left pulmonary artery
   k. pulmonic valve
   l. left pulmonary veins
   m. left atrium
   n. aortic valve
   o. bicuspid (mitral) valve
   p. left ventricle

2. a. lung
   b. ventricles
   c. right

   d. to prevent backflow of blood
   e. the outer lining of the heart
   f. myocardium

3. a. right atrium
   b. tricuspid
   c. right ventricle
   d. pulmonic
   e. left atrium
   f. bicuspid (mitral)
   g. left ventricle
   h. semilunar

Suggested Activity #5: Identification of Diseases

1. erythroblastosis fetalis
2. hemorrhage
3. anemia
4. atherosclerosis
5. coronary occlusion
6. aneurysm
7. angina pectoris
8. ischemia
9. infectious mononucleosis
10. murmur

Suggested Activity #6: Research Paper

Evaluated to the satisfaction of the instructor.

TEST / UNIT 5

The Blood and Cardiovascular System

I. Write the correct term for each of the following definitions. Choose your answer from the four choices offered.

1. the process of clotting
(serum, thrombus, coagulation, embolus) ______________ 1.

2. a cell which engulfs and destroys bacteria
and cellular debris
(phagocyte, antigen, megakaryocyte, plasma) ______________ 2.

3. any substance that stimulates the body to
produce antibodies
(antigen, megakaryocyte, reticuloendothelial
cells, matrix) ______________ 3.

4. liquid portion of coagulated blood
(plasma, lymph, serum, antibody) ______________ 4.

5. movement of leukocytes through the unbroken
capillary wall
(coagulation, agglutination, hemorrhage, diapedesis) ______________ 5.

6. the study of blood
(coagulation, electrocardiogram, embolus, hematology) ______________ 6.

7. a blood clot that has been dislodged from its
place of origin
(embolus, thrombus, fibrinolysis, node) ______________ 7.

8. intercellular material of a tissue
(agglutination, matrix, node, diapedesis) ______________ 8.

9. pertaining to mitosis or cell division
(mitotic, matrix, anticoagulant, fibrinolysis) ______________ 9.

10. small, rounded mass of tissue; a protuberance
or swelling
(thrombus, antibody, lymph, node) ______________ 10.

II. Complete the following statements.

1. Blood is a type of ____________________ tissue. ______________ 1.

2. The formed elements of the blood are the cells, the
platelets, the leukocytes, and the ______________ 2.

3. The red color of blood is due to the presence of the pigment __________ 3.

4. Iron atoms in hemoglobin combine with the element __________ 4.

5. Persons with anemia feel tired and weak because they lack red blood cells or __________ 5.

6. Three kinds of granulocytes are eosinophiles, basophiles, and __________ 6.

7. The white blood cells most active in phagocytosis are __________ 7.

8. The granulocytes that are thought to detoxify the proteins accumulated from allergic reactions are __________ 8.

9. The agranulocytes that are important in the production of antibodies are the __________ 9.

10. Platelets are vital to the __________ process. __________ 10.

11. It is thought that two opposing processes go on constantly in the tiny vessels of the circulatory system—fibrinolysis, which results in bleeding, and __________ to stop bleeding __________ 11.

12. Two antithrombins are coumarin compounds and __________ 12.

13. Antigens that cause clumping of small particles (such as blood cells) are __________ 13.

14. Two situations in which the Rh factor is important to Rh-negative individuals are pregnancy and __________ 14.

15. The part of the heart's conduction system found in the upper wall of the right atrium, also called the pacemaker, is the __________ 15.

16. A record of the electrical activity of the heart is a (an) __________ 16.

17. The pressure on blood vessels during contraction of the heart muscles is __________ 17.

18. Blood vessels that connect venules and arterioles are the __________ 18.

19. The two major circuits formed by the circulatory system are the systemic and __________ 19.

20. The lymphatic capillaries in the villi of the small intestine that collect digested fat from the digestive tract are called the __________ 20.

III. Give three main functions of the blood:

1. ______________________________

2. ______________________________

3. ______________________________

IV. Name five groups of soluble components in the blood:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

V.
1. What types of blood may be given to a Type A recipient? ____________
2. What types of blood may be given to a Type O recipient? ____________
3. What types of blood may be given to a Type AB recipient? ____________
4. Why is a second pregnancy of an Rh-negative mother with a second Rh-positive fetus possibly dangerous to the fetus?

VI. Name the three layers of the heart:

1. ______________________________

2. ______________________________

3. ______________________________

VII. Trace the course of the blood through the heart by answering the following questions.

1. Blood returning to the heart enters the ____________ 1.
2. The valve between the right atrium and the right ventricle is the ____________ 2.
3. Blood flows from the right ventricle through the pulmonic valve and pulmonary artery to the ____________ 3.
4. Blood returning to the lungs flows into the ____________ 4.
5. It flows through the bicuspid valve to the ____________ 5.

VIII. Name the components of the lymph system:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

IX. What are the functions of lymph nodes?

1. ______________________________

2. ______________________________

Name three lymph organs:

3. ______________________________

4. ______________________________

5. ______________________________

X. Match the following disease descriptions with the correct disease. Use letter answers.

_____ 1. insufficient blood supply to a given part of the body

_____ 2. dilation of veins, usually in the lower extremities

_____ 3. deficiency in the number of erythrocytes or reduced hemoglobin

_____ 4. thickening, hardening, and loss of elasticity of walls of arteries

_____ 5. closing off of a coronary artery

_____ 6. copious bleeding; excessive loss of blood

_____ 7. acute infectious disease characterized by enlargement and tenderness of lymph nodes, increase in atypical monocytes, fever, sore throat, and general malaise

_____ 8. abnormal heart sound

_____ 9. an accumulation of fats and other substances in the arteries

_____10. severe chest pain caused by an insufficient flow of blood to the heart

a. anemia

b. aneurysm

c. angina pectoris

d. arteriosclerosis

e. atherosclerosis

f. coronary occlusion

g. erythroblastosis fetalis

h. hemorrhage

i. infectious mononucleosis

j. ischemia

k. murmur

l. varicose veins

ANSWERS TO TEST

I.

1. coagulation
2. phagocyte
3. antigen
4. serum
5. diapedesis
6. hematology
7. embolus
8. matrix
9. mitotic
10. node

II.

1. connective
2. erythrocytes
3. hemoglobin
4. oxygen
5. hemoglobin
6. neutrophiles
7. neutrophiles
8. eosinophiles
9. lymphocytes
10. clotting (coagulation)
11. coagulation (stop bleeding)
12. heparin
13. agglutinogens
14. transfusion
15. sinoatrial node
16. electrocardiogram
17. systole
18. capillaries
19. systemic
20. lacteals

III.

1. transportation
2. regulates and equalizes body temperature
3. defends body against invasion by bacteria and viruses

IV.

1. plasma proteins (albumins, globulins, fibrinogen)
2. nutrients (glucose, lipids, amino acids)
3. organic wastes (urea, uric acid, ammonia salts, creatine)
4. inorganic salts
5. oxygen and carbon dioxide
6. regulatory substances (enzymes and hormones)

V.

1. A, O*
2. O
3. A*, B*, AB, O*
   (*In actual practice, blood of the same type as the recipient is usually given.)
4. The mother may have Rh antibodies, and these may react with fetal antigens, causing hemolysis of fetal red blood cells.

VI.

1. epicardium
2. myocardium
3. endocardium

VII.

1. right atrium
2. tricuspid
3. lungs
4. left atrium
5. left ventricle

VIII.

1. lymphatic capillaries
2. lymph ducts
3. lymph organs
4. lymph nodes
5. lymph

IX. 1. Phagocytes destroy microorganisms and cellular debris.
2. produce lymphocytes
3. spleen
4. tonsils
5. thymus gland

X. 1. j
2. l
3. a
4. d
5. f
6. h
7. i
8. k
9. e
10. c

Unit 6

The Respiratory System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the respiratory system;
2. distinguish between breathing (pulmonary ventilation) and external and internal respiration;
3. identify the parts of the respiratory system, and give the function of each;
4. trace the pathway of inspired and expired air through the respiratory system;
5. locate the parts of the respiratory system on a diagram;
6. locate and give the functions of the sinuses;
7. name the seven openings into the pharynx;
8. tell how sound is produced by the vocal cords;
9. describe the Heimlich maneuver;
10. explain how air is caused to flow in and out of the lungs;
11. identify types of breathing;
12. explain the movement of gases between alveolar walls and the blood;
13. tell how oxygen and carbon dioxide are transported in the blood;
14. explain how breathing is controlled by the nervous system and chemical stimulation;
15. describe cardiopulmonary resuscitation; and
16. identify common diseases of the respiratory system.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Identification of the Parts of the Face and Neck"
The identification of body parts on a diagram makes it easier for students to develop a concept of the location of parts and their relation one to the other.

Suggested Activity #2: "Identification of Parts of the Respiratory Tract"
See above.

Suggested Activity #3: "Practice with New Terms"
This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #4: "Mechanics of Breathing"
This demonstration is designed to help students realize the mechanical process by which air enters and leaves the respiratory system.

Suggested Activity #5: "The Effect of Abnormal Quantities of Carbon Dioxide in the Blood"

Students can easily demonstrate to themselves the changes that take place in respiratory rate when the amount of carbon dioxide varies.

Suggested Activity #6: "Demonstration of the Heimlich Maneuver"

All students should be able to perform the Heimlich maneuver. Demonstration by an outside professional may encourage students to take this exercise seriously.

Suggested Activity #7: "Demonstration of CPR"

All students should be able to perform CPR satisfactorily.

Suggested Activity #8: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 6

Review Questions

1. Define **respiration.**
2. Differentiate between external and internal respiration.
3. Define **expiration** (exhalation) and **inspiration** (inhalation).
4. Name three ways that air is prepared for entry into the bronchi in the nasal passage.
5. Where are the olfactory receptors?
6. What are the functions of the sinuses?
7. Name the seven openings into the pharynx.
8. How is air pressure on the middle ear equalized?
9. How are vocal sounds produced?
10. Why does hoarseness and even loss of voice occur with laryngitis?
11. Trace the path of inspired air into the lungs by arranging the following names of parts in correct sequence: trachea, larynx, nares, nasal passage, alveoli, bronchi, alveolar duct, pharynx, glottis, bronchioles.
12. What is the result of tracheal obstruction?
13. What structures actually make up the lungs?
14. How does the diaphragm function in breathing?
15. How is breathing controlled?
16. What is surfactant?
17. Name and describe four types of breathing.
18. Define **diffusion.**
19. By what process does oxygen leave the blood and enter the body cells?
20. Under what circumstance will carbon dioxide leave body cells and enter venous blood?
21. What are the three end products of cellular respiration?

ANSWERS TO REVIEW QUESTIONS

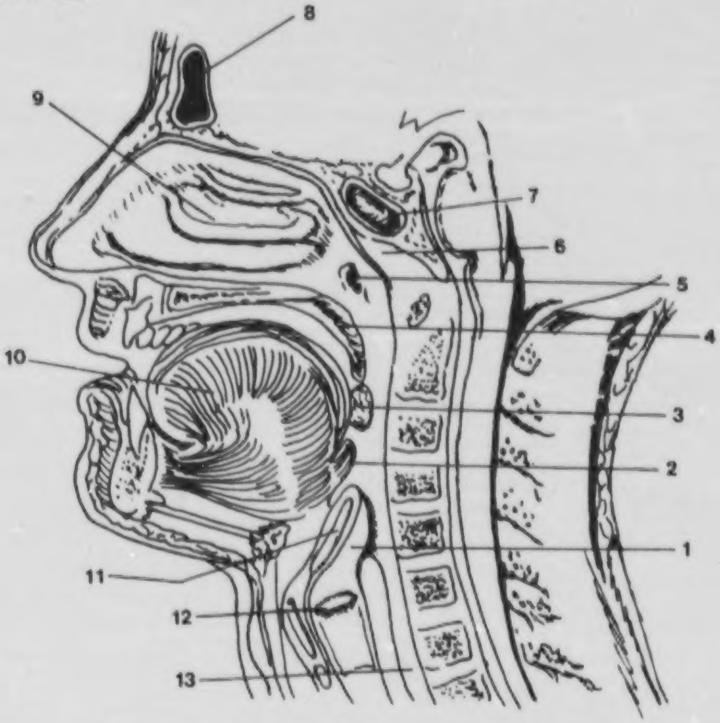
1. Respiration is the taking in of oxygen, its utilization in the cells, and the removal of carbon dioxide produced by body cells.
2. **External** respiration refers to the exchange of gases between the lungs and the blood. **Internal** respiration means the exchange of gases between the blood and body cells.
3. **Expiration** means to breathe out; **inspiration** means to breathe in.
4. (1) Cilia filter out impurities.
   (2) Bacteria and debris are trapped on the mucosal surface.
   (3) Air is warmed and moistened.
5. The olfactory receptors are in the nasal mucosa in the upper portion of the nasal cavity.
6. reduce the weight of the skull, provide mucus for the nasal cavity, and enhance the resonance of the voice
7. mouth, nares (2), esophagus, larynx, and eustachian tubes (2)
8. Air entering the middle ear from the pharynx by way of the eustachian tubes equalizes the pressure on the eardrum from air entering the outer ear.
9. Air passing over the vocal cords causes them to vibrate.
10. The vocal cords swell so they cannot vibrate.
11. nares, nasal passage, pharynx, glottis, larynx, trachea, bronchi, bronchioles, alveolar ducts, alveoli
12. asphyxiation
13. bronchioles, alveolar ducts, and alveoli
14. As the diaphragm contracts, it moves downward increasing the volume of the chest cavity. As it relaxes, it moves upward and forces air out of the lungs.
15. neural control—by means of the medulla of the brain, and the vagus and phrenic nerves and their branches.
    chemical control—by increased carbon dioxide level in the blood.
    mechanical control—as air pressure in the lungs equals atmospheric pressure, the diaphragm and intercostal muscles contract, the volume of the chest cavity increases, and air flows in.
16. a phospholipid produced by alveolar cells that lines the alveoli and keeps the walls from sticking together
17. (1) eupnea—normal, quiet breathing
    (2) apnea—cessation of breathing
    (3) hyperpnea—abnormally increased breathing
    (4) Cheyne-Stokes breathing—respirations gradually increase in rapidity and volume until they reach a climax, then gradually subside, cease entirely for a few seconds, then begin the cycle again.
18. the movement of molecules from a region of higher concentration of molecules to a region of lower concentration of molecules
19. diffusion
20. when the concentration of carbon dioxide in the cells is greater than the concentration of carbon dioxide in the blood
21. carbon dioxide, water, energy

Suggested Activity #1: Identification of the Parts of the Face and Neck UNIT 6

Objective: To identify the parts of the face and neck that are pertinent to the respiratory system.

Procedure: Use available materials, such as models, charts, and text illustrations, to identify the parts listed. Label these parts on the accompanying diagram:

frontal sinus
sphenoid sinus
pharyngeal tonsil
palatine tonsil
lingual tonsil
nasal cavity (3 conchae)
eustachian tube
epiglottis
vocal cords
larynx
esophagus
pharynx
tongue



1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________
9. ______________________
10. ______________________
11. ______________________
12. ______________________
13. ______________________

Suggested Activity #2: Identification of Parts of the Respiratory Tract UNIT 6

Objective: To identify the parts of the respiratory tract from a model and to label the parts on a diagram

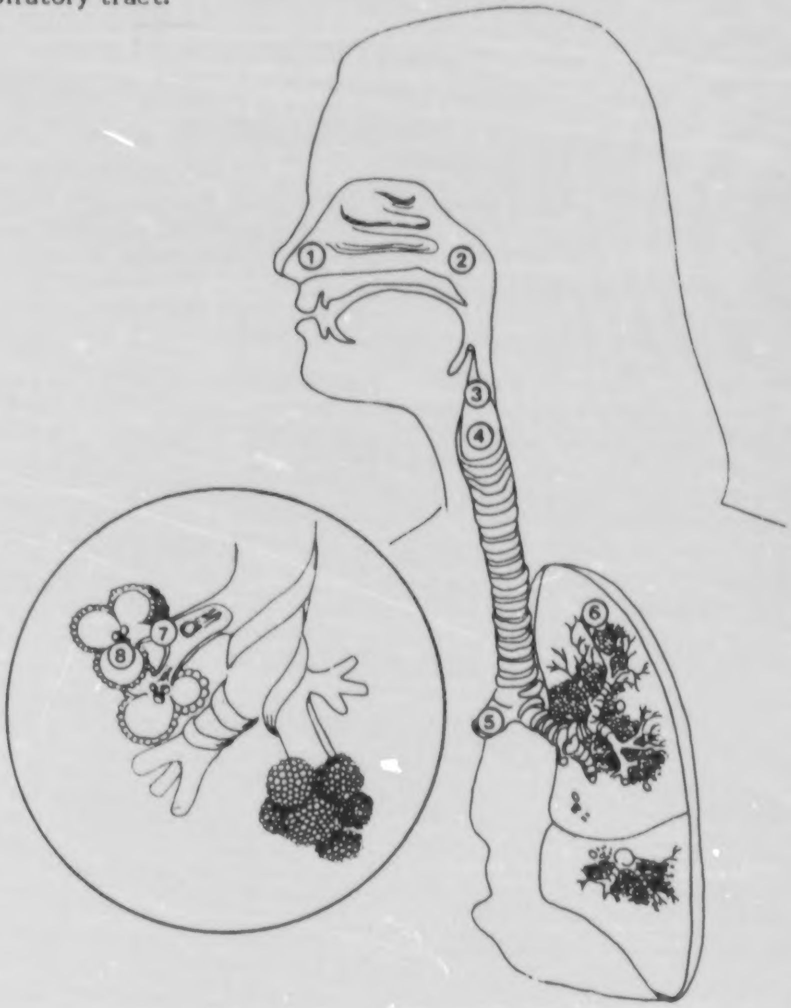
Procedure:

1. Using a human torso model or chart if available, note the location of the parts listed and their relation to other parts of the respiratory system.

   nose
   pharynx
   larynx
   trachea
   bronchus
   bronchioles
   alveolar duct
   alveolus

2. Write the names of the numbered structures on the diagram of the parts of the respiratory tract.

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________
7. ______________
8. ______________



Suggested Activity #3: Practice with New Terms UNIT 6

Objective: To become familiar with new terms used in studying the respiratory system

Materials: List of new terms and definitions for this unit in the student's manual.

Procedure: Rearrange the letters below to form words used in studying the respiratory system.

1. FYOLRATOC 1. __ __ __ __ __ __ __ __ __ __
2. TROSTCLANIE 2. __ __ __ __ __ __ __ __ __ __ __
3. SYXHATIANOIP 3. __ __ __ __ __ __ __ __ __ __ __ __
4. CURTFASTAN 4. __ __ __ __ __ __ __ __ __ __ __
5. LRUPALE 5. __ __ __ __ __ __ __
6. GRETHANIB 6. __ __ __ __ __ __ __ __ __
7. NATIPONIRIS 7. __ __ __ __ __ __ __ __ __ __ __
8. LOVEIAL 8. __ __ __ __ __ __ __
9. DILITACE 9. __ __ __ __ __ __ __ __
10. ISSUN 10. __ __ __ __ __
11. PRANIXITOE 11. __ __ __ __ __ __ __ __ __ __
12. IRRIPONATES 12. __ __ __ __ __ __ __ __ __ __ __

Objective: To demonstrate the function of the diaphragm in breathing

Materials:
Bell jar
1-hole rubber stopper
Y-shaped glass tubing
2 balloons
Rubber diaphragm to cover bottom of jar
Fixative (string and glue to attach diaphragm to jar)

Procedure:
1. Attach a balloon to each side of the "y" glass tubing.
2. Insert the stem of the "y" tubing in the rubber stopper. (A 2-hole stopper and two pieces of glass may be used, but the results are less dramatic.)
3. Affix the diaphragm to the bottom of the bell jar, using string and fixative to make it airtight. Do not stretch it tightly over the bottom of the jar.
4. Pull down on the center of the diaphragm, and note movement of balloons.
5. Release diaphragm, and note movement of balloons.

The bell jar simulates the chest cavity, the tubing simulates the trachea and bronchi, the balloons simulate the lungs, and the diaphragm represents the diaphragm of the body.

Results:
1. What happens to the balloons when the diaphragm is pulled down? Why?
2. What happens to the balloons when the diaphragm is released? Why?
3. Describe the body function simulated in this experiment.

Suggested Activity #5: The Effect of Abnormal Quantities of Carbon Dioxide in the Blood

Objective: To determine the effect of variations in quantities of carbon dioxide in the blood

Materials: Brown paper bag
Watch

Procedure: Students will work in pairs.

1. Count and record your partner's respirations while seated and relaxed for 2 minutes.
2. Ask your partner to hyperventilate by breathing deeply and rapidly for 2 minutes. Record respiration rate.
3. Look for a brief period of apnea immediately following hyperventilation.
4. Ask your partner to hyperventilate for 2 minutes into a paper bag held tightly over the nose and mouth.
5. Immediately count and record his/her respirations for one minute.

Results:

1. What was the resting respiration rate? ______________
2. What was the respiration rate after 2 minutes of hyperventilation? ______________
3. Was there a brief period of apnea immediately following hyperventilation? ______________
4. What happens to the level of carbon dioxide in the blood during hyperventilation into the paper bag? ______________
5. How will the carbon dioxide level be restored to normal?

Suggested Activity #6: Demonstration of Heimlich Maneuver

Objective: To demonstrate the Heimlich maneuver so students may learn this lifesaving technique.

Procedure: Invite a professional, such as a paramedic or emergency medical technician, to demonstrate the procedure. The professional may then work with individual class members in learning the technique, taking great care to prevent discomfort to participants.

Results:

1. Why is a blocked airway a cause for immediate concern?
2. Why are the lungs usually filled as aspiration of foreign body or food occurs?
3. Why does the pressure on the diaphragm usually dislodge the object?
4. What are indications (or signs) that a patient has an airway obstruction?

All students in health occupations education should be proficient in cardiopulmonary resuscitation. The instructor may wish to invite a person from a national association such as the American Red Cross or the American Heart Association to present this to students. It is imperative that each student practice on mannequins until she/he feels capable of performing CPR.

Suggested Activity #8: Research Paper

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper. Suggested topics are:

- Respiratory Therapy as a Career
- The Relation of Gas Laws to Human Respiration
- Rights of Individuals in Regard to Smoking
- Problems of Air Pollution as They Relate to Respiration

Topic should reflect individual student interest. Often the topic could provide the student with information regarding a specific career.

Results: The research paper should be evaluated to the satisfaction of the instructor.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Identification of the Parts of the Face and Neck

1. larynx
2. lingual tonsil
3. palatine tonsil
4. pharynx
5. eustachian tube
6. pharyngeal tonsil (adenoid)
7. sphenoid sinus
8. frontal sinus
9. nasal cavity (conchae)
10. tongue
11. epiglottis
12. vocal cords
13. esophagus

Suggested Activity #2: Identification of Parts of the Respiratory Tract

1. nose
2. pharynx
3. larynx
4. trachea
5. bronchus
6. bronchiole
7. alveolar duct
8. alveolus

Suggested Activity #3: Practice with New Terms

1. olfactory
2. intercostal
3. asphyxiation
4. surfactant
5. pleural
6. breathing
7. inspiration
8. alveoli
9. ciliated
10. sinus
11. expiration
12. respiration

Suggested Activity #4: Mechanics of Breathing

1. The balloons fill with air. Air is pulled into the bell jar and balloons as the volume in the bell jar is increased by lowering the diaphragm.
2. As the diaphragm is released, the balloons deflate. The volume in the bell jar is decreased as the diaphragm snaps back into place; air is forced out of the jar and balloons.
3. It simulates the expansion of the chest on inspiration because of the action of the intercostal muscles and the diaphragm.

Suggested Activity #5: The Effect of Abnormal Quantities of Carbon Dioxide in the Blood

1. Answers will vary. Normal respiration is 15 to 20 breaths/minute.
2. Answers will vary, but rate should be increased.
3. yes
4. The carbon dioxide level is increased.
5. It is restored to normal by breathing recycled, exhaled air.

Suggested Activity #6: Demonstration of Heimlich Maneuver

1. If the trachea is obstructed for even a short time, death will result from asphyxiation.
2. Food choking usually occurs during inspiration, when the lungs are expanded.
3. Pressure on the diaphragm forces air out of the lungs against the lodged article.
4. Patient cannot speak or breathe. Patient usually panics. Patient becomes pale, then cyanotic. Patient loses consciousness.

Suggested Activity #7: Demonstration of CPR

Evaluated to the satisfaction of the instructor.

Suggested Activity #8: Research Paper

Evaluated to the satisfaction of the instructor.

TEST / UNIT 6

The Respiratory System

I. Match the following terms with the phrases using letter answers.

____ 1. to breathe in (inhalation)

____ 2. pertaining to the chest region

____ 3. condition caused by insufficient intake of oxygen; suffocation

____ 4. the exchange of gases between the blood and the body cells

____ 5. covered with short, bristlelike hairs

____ 6. pertaining to the lungs

____ 7. phospholipid produced by the alveoli; forms a lining that prevents the thin membranes of the alveoli from sticking together

____ 8. the tissues covering the lungs and lining the chest cavity. The two pleural surfaces move over each other.

____ 9. cavity

____ 10. mechanical process by which atmospheric air is taken into the lungs and waste is expelled

____ 11. to breathe out (exhalation)

____ 12. between the ribs; refers to muscles

____ 13. the exchange of gases between the lungs and the blood

____ 14. device to measure the air capacity of the lungs

____ 15. bluish gray skin color caused by lack of oxygen in the blood

____ 16. minute, balloonlike sacs in the lung, through which oxygen and carbon dioxide are exchanged

____ 17. the part of the brain that controls respiration

____ 18. pertaining to the sense of smell

a. alveoli

b. asphyxiation

c. breathing

d. ciliated

e. cyanosis

f. expiration

g. external respiration

h. inspiration

i. intercostal

j. internal respiration

k. medulla

l. olfactory

m. pleural

n. pulmonary

o. sinus

p. spirometer

q. surfactant

r. thoracic

II. Complete the following statements:

1. Oxygen is transported from the lungs to the body cells by the capillaries of the ________________ system. ________________ 1.

2. Air is moved in and out of the lungs by the process of ________________ or pulmonary ventilation. ________________ 2.

3. Dust, dirt, debris, and bacteria are removed from the air as it passes over the nasal passage by ________________ 3.

4. The eustachian tube equalizes pressure on the ________________ 4.

5. The three pairs of tonsils are the pharyngeal (adenoids), palatine, and ________________ 5.

6. The true name of the "voicebox" is the ________________ 6.

7. The thin sheet of muscle that separates the chest and abdominal cavities is the ________________ 7.

8. Most of the oxygen transported in the blood is carried in the ________________ of red blood cells. ________________ 8.

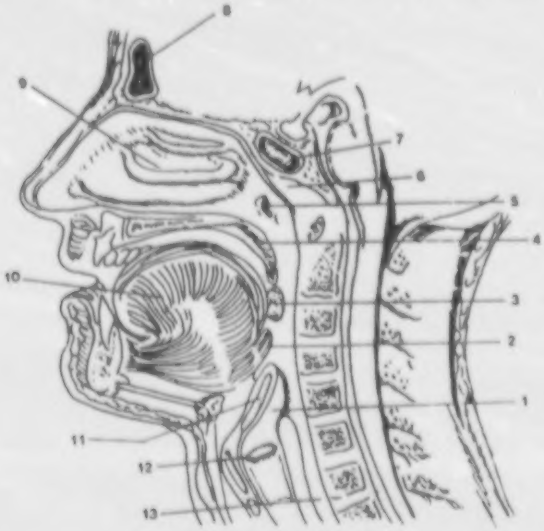
9. Breathing is controlled by the nervous system and by ________________ 9.

10. An increase in the ________________ level in the blood stimulates increased breathing. ________________ 10.

11. Normal, quiet breathing is called ________________ 11.

12. The two main nerves that control breathing are the phrenic and the ________________ 12.

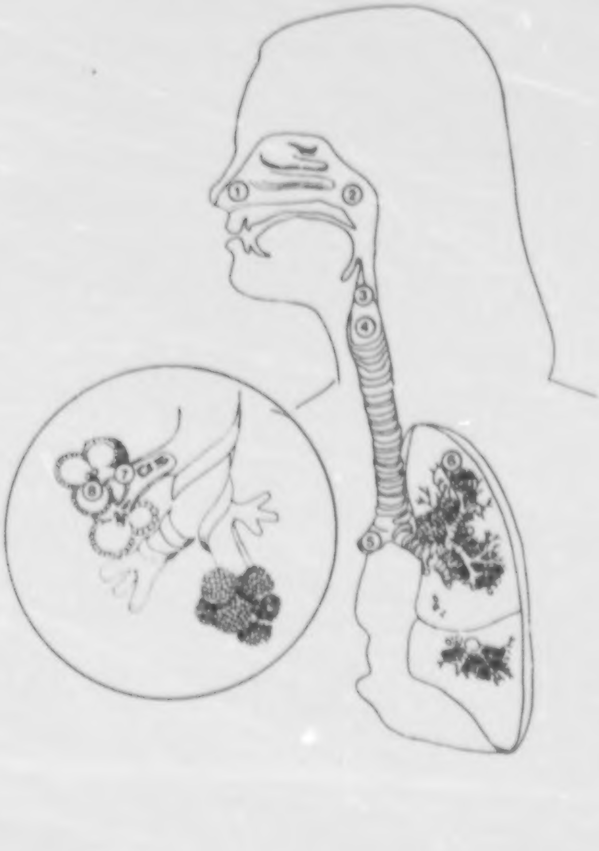
III. Identify the numbered parts of the diagram of the nose and throat.



1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________

IV. Write the names of the numbered parts of the diagram of the respiratory system.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________



V. Short answer questions:

1. Give three functions of the sinuses:

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. Give identifying characteristics of a patient who is choking because of obstruction of the airway:

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Complete the following sentences, which explain how air enters and leaves the lungs, by writing **increases** or **decreases** in the blank spaces.

   a. As the diaphragm and intercostal muscles contract, the size of the chest cavity ________________.

   b. The pressure within the lungs ________________ and air enters the lungs.

   c. As the pressure in the lungs ________________ as a result of inspiration, air flows out of the lungs.

4. Complete the following sentences explaining the movement of gases in external and internal respiration, by writing **enter** or **leave** in the blank spaces.

   a. If the PO_2 of alveoli is greater than the PO_2 of blood in the capillaries, oxygen will ________________ the alveoli.

   b. If the PO_2 of the blood is greater than the PO_2 of body cells, oxygen will ________________ the cells.

   c. If PCO_2 is greater in blood than in the alveoli, carbon dioxide will ________________ the alveoli.

VI. The following are descriptions of diseases of the respiratory tract. Write the correct name of the disease from the four choices offered.

1. acute, contagious respiratory infection characterized by inflammation of the upper respiratory tract, generalized aches, and fever (influenza, pleurisy, atelectasis, laryngitis) ____________ 1.

2. inflammation of the pharynx; sore throat (cough, common cold, pharyngitis, pleurisy) ____________ 2.

3. respiratory disease of the newborn; the infant lacks surfactant, so the alveoli tend to collapse (hyaline membrane disease, pleurisy, atelectasis, pneumonia) ____________ 3.

4. infection and inflammation of the alveoli; may be caused
by viruses, bacteria, or chemical irritants
(tuberculosis, common cold, influenza, pneumonia) ______________ 4.

5. collapse of part or all of a lung with incomplete expansion
of the alveoli
(bronchiectasis, atelectasis, emphysema, asthma) ______________ 5.

6. inflammation of a sinus
(sinusitis, epistaxis, hyaline membrane disease, asthma) ______________ 6.

7. most widespread of all communicable diseases;
characterized by swollen and inflamed mucous membrane
of the nose and throat
(laryngitis, epistaxis, cough, common cold) ______________ 7.

8. swelling or distention of air passages and alveoli;
the alveoli remain filled with air during expiration
(emphysema, bronchiectasis, asthma, tuberculosis) ______________ 8.

9. inflammation of the pleura or lining of the lungs
(sinusitis, pharyngitis, laryngitis, pleurisy) ______________ 9.

10. mechanism for clearing obstruction from the airway
(cough, laryngitis, epistaxis, hyaline membrane disease) ______________ 10.

ANSWERS TO TEST

I.
1. h
2. r
3. b
4. j
5. d
6. n
7. q
8. m
9. o
10. c
11. f
12. i
13. g
14. p
15. e
16. a
17. k
18. l

II.
1. circulatory
2. breathing
3. cilia
4. tympanic membrane (eardrum)
5. lingual
6. larynx
7. diaphragm
8. hemoglobin
9. chemical stimulation
10. carbon dioxide
11. eupnea
12. vagus

III.
1. larynx
2. lingual tonsil
3. palatine tonsil
4. pharynx
5. eustachian tube
6. pharyngeal tonsil (adenoid)
7. sphenoid sinus
8. frontal sinus
9. nasal cavity (conchae)
10. tongue
11. epiglottis
12. vocal cords
13. esophagus

IV.
1. nose
2. pharynx
3. larynx
4. trachea
5. bronchus
6. bronchiole
7. alveolar duct
8. alveolus

V.
1. a. reduce the weight of the skull
   b. provide mucus for nasal cavity
   c. enhance resonance of the voice
2. Any three of these four:
   a. cannot speak
   b. usually panics
   c. becomes pale and cyanotic
   d. ultimately loses consciousness
3. a. increases
   b. increases
   c. decreases
4. a. leave
   b. enter
   c. enter

VI.
1. influenza
2. pharyngitis
3. hyaline membrane disease
4. pneumonia
5. atelectasis
6. sinusitis
7. common cold
8. emphysema
9. pleurisy
10. cough

Unit 7

The Nervous System and Special Senses

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the nervous system and special senses;
2. identify the main parts of the nervous system;
3. locate and give the functions of the parts of the brain;
4. explain the importance of a constant oxygen supply to the brain;
5. tell how the meninges and cerebrospinal fluid protect the brain;
6. locate the spinal cord;
7. give the function of cranial and spinal nerves;
8. describe the autonomic nervous system;
9. tell the function of each part of a neuron, and of three types of neurons;
10. list types of neuroglia;
11. describe the pathway of stimulus to response;
12. describe a reflex arc;
13. name and locate the major parts of the ear;
14. list the parts of the ear concerned with balance and equilibrium;
15. trace the pathway of auditory stimulation to the brain;
16. name and locate the major parts of the eye;
17. list accessory parts of the eye;
18. identify common errors in vision;
19. discuss the perception of odors;
20. tell why pain is a protective sense; and
21. identify common diseases and disorders of the nervous system and special senses.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Reflex Activity"

This activity is designed to provide an opportunity for students to demonstrate reflex action. Actually seeing this movement makes the text description clearer.

Suggested Activity #3: "Identification of Parts of the Brain"

Study of the diagrams and model (if available) and identification of the parts will enhance the descriptions given in the text.

Suggested Activity #4: "Identification of Parts of a Neuron"

It is not feasible to use an actual neuron for this study, but students will have a better concept of the structure and modifications of neurons by studying the diagrams.

Suggested Activity #5: "Identification of Parts of the Ear"

Study of the model and diagrams of the ear and identification of the parts will make it easier for students to understand the process of hearing.

Suggested Activity #6: "Identification of Parts of the Eye"

Study of the model and diagrams of the eye and identification of the parts will make it easier for students to understand the process of seeing.

Suggested Activity #7: "Identification of Diseases and Disorders of the Nervous System and Special Senses"

This exercise provides practice in recognition of the correct terms to match definitions. Reading the definitions for identification reinforces recognition.

Suggested Activity #8: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 7

Review Questions

1. Name the two main parts of the nervous system, and list the components of each.
2. What are the three main functional areas of the cerebrum?
3. Where is the cerebellum located?
4. What are the functions of the cerebellum?
5. What does the word **pons** mean?
6. Which cranial nerves originate in the pons?
7. Name two endocrine glands found in the cranial cavity.
8. What two structures are connected by the medulla?
9. What are three vital control centers in the medulla?
10. What is the result of oxygen deprivation to nerve cells of the brain?
11. What happens if the brain is deprived of glucose?
12. Where is cerebrospinal fluid found?
13. Describe the location of the spinal cord.
14. What is its function?
15. What are the three layers of the meninges?
16. What are peripheral nerves?
17. What body parts are served by cranial nerves?
18. What does the automatic nervous system control?
19. What is the difference between the **sympathetic** and **parasympathetic** nervous systems?
20. Name two kinds of nerve cells.
21. Name the function of the following parts of a neuron: (a) Nissl body, (b) neurofibril, (c) axon, (d) dendrite.
22. Why are nerve cells in the brain and spinal cord unable to regenerate?
23. Why are neurons of the central nervous system not replaced if lost or damaged?
24. Name three types of neurons and tell what each does.
25. Name three kinds of neuroglia and give the function of each.
26. What is a **synapse**?
27. Give the route of conduction of an impulse through a reflex arc.
28. Why are reflex actions protective?
29. Name the parts of the outer ear and give their function.
30. What is the function of the eustachian tube?
31. What are the **ossicles** of the middle ear?
32. Name the parts of the labyrinth or inner ear.
33. With what function are the semicircular canals and the utricle and saccule concerned?
34. In a sentence tell how we actually hear.
35. What are the three layers that make up the eyeball?
36. Why would clouding or scarring of the cornea affect sight?
37. In which layer of the eye is the iris found?
38. What is the **pupil** of the eye?
39. What is the function of the ciliary muscle?
40. What do the rods and cones of the retina do?
41. Name the four refracting media of the eye.
42. What is the function of the lacrimal apparatus?
43. Name four other accessory parts of the eye.
44. Define the following defects in vision: myopia, hyperopia, and astigmatism.
45. In what form must a substance be before its odor can be perceived?
46. Why is pain a defense mechanism?

47. What is **referred pain**?
48. Name six other senses.

ANSWERS TO REVIEW QUESTIONS

1. (1) central nervous system—brain and spinal cord
   (2) peripheral nervous system—cranial nerves, spinal nerves, autonomic nerves, and ganglia
2. (1) sensory
   (2) motor
   (3) association (integrative)
3. It is dorsal to the pons and medulla but below the posterior portion of the cerebrum.
4. It controls the subconscious movements of skeletal muscles and regulates the smooth, coordinated movements of skeletal muscles. It also functions in the control of equilibrium and posture.
5. bridge
6. V, VI, VII, and VIII
7. pituitary and pineal
8. brain and spinal cord
9. heartbeat, respiration, and blood pressure
10. Brain cells first become weakened, and unconsciousness may occur. Four minutes of deprivation may cause permanent injury, brain damage, or even death.
11. dizziness, confusion, convulsions, and loss of consciousness
12. in and around the brain and spinal cord
13. in the spinal canal, encased in vertebrae and extends from the medulla to the second lumbar vertebra
14. It contains centers for reflex action and serves as a two-way conduction path between the brain and nerves to trunk and limbs.
15. (1) dura mater
    (2) arachnoid membrane
    (3) pia mater
16. nerves that extend to the outlying parts of the body
17. structures of the head, neck, thoracic, and abdominal cavities
18. involuntary or automatic functions of the body
19. The sympathetic prepares the body for stressful situations. The parasympathetic acts as a balance for the sympathetic and brings about a return to normal.
20. neurons and neuroglia
21. (a) Nissl bodies synthesize protein.
    (b) Neurofibrils provide support.
    (c) Axons transmit impulses away from the nerve cell body.
    (d) Dendrites transmit impulses to the nerve cell body.
22. They lack the neurilemma that is essential to regeneration.
23. They lack the mitotic apparatus needed for cell division.
24. (1) sensory neurons—transmit impulses to spinal cord
    (2) motor neurons—transmit impulses away from spinal cord
    (3) connecting neurons—conduct impulses from sensory to motor neurons
25. (1) astrocytes—support
    (2) oligodendrocytes—support
    (3) microglia—move to areas of inflamed or damaged nerve tissue where they phagocytize microbes and destroy cellular debris
26. a minute space between the dendrite of one neuron and the axon of another
27. from receptor of sensory neuron to synapse to interneuron to synapse to motor neuron to effector
28. They occur quickly before danger or pain is actually perceived.

29. The auricle (pinna) collects and directs sound waves into the **auditory canal** (meatus) and then to the tympanic membrane.
30. to equalize air pressure on the tympanic membrane
31. three tiny bones—the malleus, incus, and stapes
32. the vestibule, the cochlea, and semicircular canals
33. equilibrium or balance
34. Sound waves are transmitted through the parts of the ear in succession until the auditory nerve is stimulated.
35. the sclera, choroid, and retina
36. It would decrease the amount of light that could enter the eye.
37. in the choroid
38. an opening in the iris
39. It controls the shape of the lens.
40. The rods receive stimuli that make it possible to distinguish shapes and shades in light and dark. The cones are stimulated by bright light and perceive color and detail.
41. cornea, aqueous humor, lens, vitreous humor
42. to produce and drain tears
43. eyebrows, eyelids, eyelashes, and conjunctiva
44. myopia--light rays focus in front of the retina
    hyperopia—light rays would focus at a point behind the retina
    astigmatism—curvature of lens or cornea (or both) is uneven
45. It must be in the form of gaseous particles.
46. It warns of danger to the body.
47. It is pain in one part of the body that is interpreted as coming from another part.
48. hunger, thirst, pressure, temperature, position, and touch

Suggested Activity #1: Practice with New Terms UNIT 7

Match the following terms with definitions using letter answers.

_____ 1. small bone

_____ 2. a hollow in a part for another organ

_____ 3. coming from within

_____ 4. end of a dendrite of a sensory neuron

_____ 5. muscles or glands that respond to stimulation in reflex arc

_____ 6. a groove, cleft, or slit

_____ 7. to bend; to deflect

_____ 8. shallow grooves in the surface of the brain

_____ 9. an involuntary response to a stimulus

_____ 10. pain that the body interprets as coming from one part of the body when the pain originates in some other area

_____ 11. neurons that transmit impulses to the spinal cord

_____ 12. nerve cells found in the brain that have supporting or repair functions

_____ 13. coming from without

_____ 14. away from the center; toward the outside of the body

_____ 15. dark pigment that gives color to hair, skin, and eyes

_____ 16. pertaining to tears

_____ 17. mass of nerve tissue outside the spinal cord or brain

_____ 18. minute space between the dendrite of one neuron and the axon of another

_____ 19. nerve cell body and its extensions

_____ 20. passage or opening

a. effectors
b. extrinsic
c. fissure
d. foramen
e. ganglion
f. intrinsic
g. lacrimal
h. meatus
i. melanin
j. motor neurons
k. neuroglia
l. neuron
m. ossicle
n. peripheral
o. pneumotaxic
p. receptor
q. referred pain
r. reflex
s. refract
t. sensory neuron
u. socket
v. sulci (sulcus)
w. synapse

Suggested Activity #2: Reflex Activity

Objective: To demonstrate a reflex action

Materials:

Rubber hammer
Flashlight
Cotton
Tongue blade
Wooden applicator stick with wisp of cotton

Procedure:

1. Ask your partner to sit down, cross his/her legs, and close eyes.
2. Using the rubber hammer, tap the area over the patellar tendon gently. This response is called the patellar reflex.
3. Ask your partner to rest one knee on a chair with the foot and ankle extended. Bend the foot to stretch the Achilles tendon. Tap the skin over the tendon with the hammer. This demonstrates the Achilles reflex.
4. Ask your partner to open the mouth. Use tongue blade to depress tongue. Touch the uvula with the wisp of cotton, and note the results. This demonstrates the pharyngeal reflex.
5. Seat your partner comfortably. Gently stroke the hairs on one side of the back of the neck, then on the other side. Note the resulting change in the size of the pupil as each side is stroked.

Results:

1. Describe the patellar reflex.
2. Describe the Achilles reflex.
3. What happened as a result of stimulation of the uvula?
4. Describe any changes in pupillary size, and tell which eye responded.

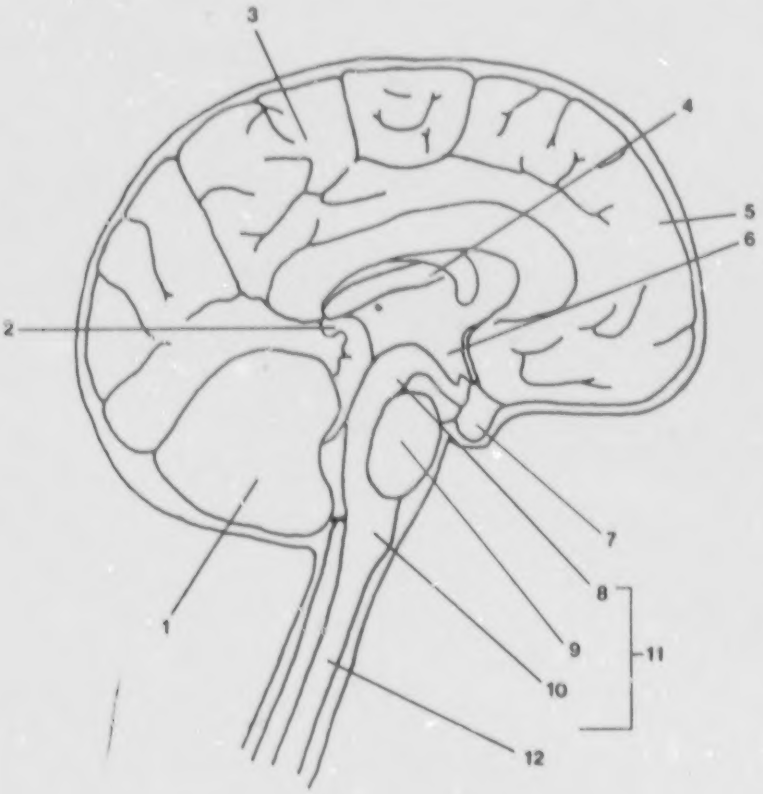
Suggested Activity #3: Identification of Parts of the Brain

Objective: To learn the location of the major parts of the brain and their relation to each other

Materials: Diagram of sagittal section of brain (fig. 1)
Model of brain (if available)

Procedure:
1. Review the names and locations of parts of the brain shown in figures 1 and 2.
2. Identify parts of the brain using the model.

Results: Label the diagram of the brain without using references.

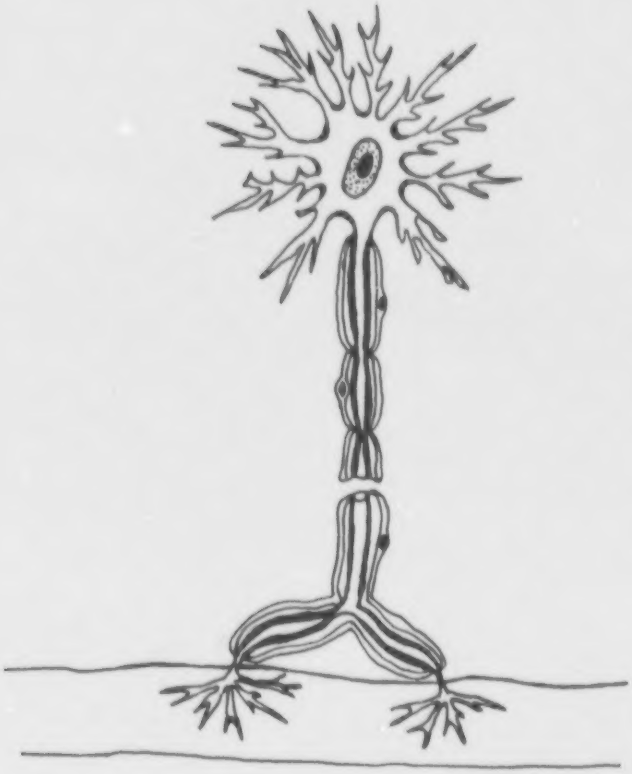


Objective: To identify the parts of a motor neuron

Materials: Diagram of a motor neuron (fig. 4B)
Model of a neuron (if available)

Procedure:
1. Review the parts of a motor neuron.
2. Identify the parts of a neuron using the model.

Results: Label the diagram of a motor neuron without using references.

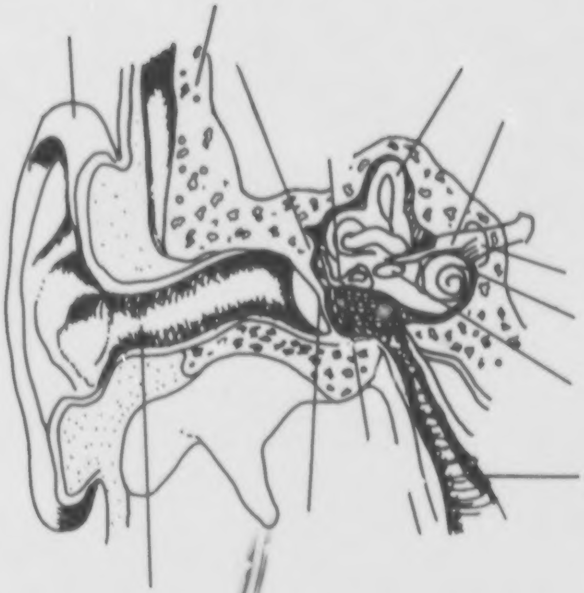


Objective: To identify the parts of the ear

Materials: Diagram of the ear (fig. 7)
Model of the ear (if available)

Procedure:
1. Review the parts of the ear shown in figure 7.
2. Identify the parts of the ear from the model.

Results: Label the diagram of the ear without using references.

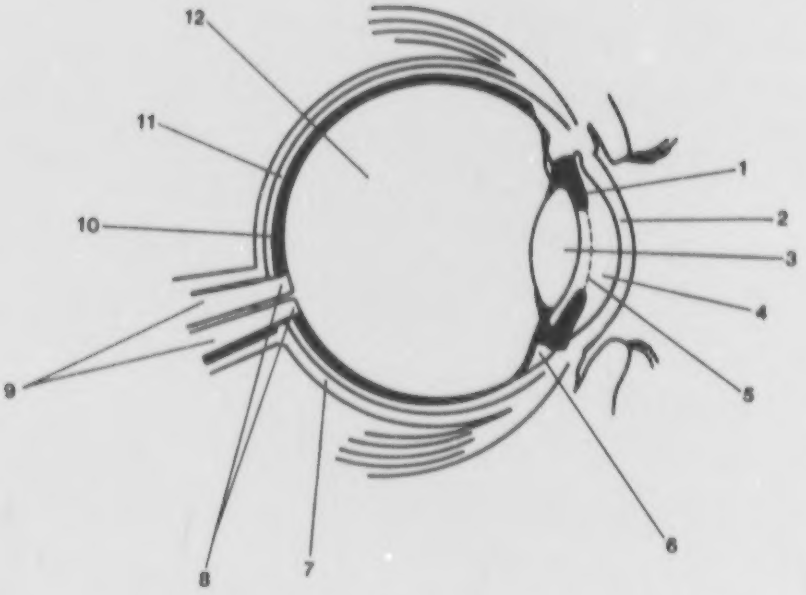


Objective: To identify the parts of the eye

Materials: Diagram of the eye (fig. 9)
Model of the eye (if available)

Procedure:
1. Review the parts of the eye shown in figure 9.
2. Identify the parts of the eye from the model.

Results: Label the diagram of the eye without using references.



Suggested Activity #7: Identification of Diseases and Disorders of the Nervous System and Special Senses

Objective: To identify common diseases and disorders of the nervous system and special senses

Procedure: Write the name of the correct disease or disorder for each of the following descriptions. The diseases are listed below:

astigmatism
cataract
cerebral palsy
conjunctivitis
cerebrovascular accident (CVA)
encephalitis
epilepsy
glaucoma
hyperopia (hypermetropia)
meningitis
motion sickness
multiple sclerosis
myopia
otitis media
otosclerosis
paralysis
poliomyelitis
tinnitus
vertigo

1. infection of the brain ____________ 1.

2. defect in vision in which light rays focus behind the retina ____________ 2.

3. ringing or buzzing sound in the ear ____________ 3.

4. temporary or permanent loss of function; especially of sensation or voluntary motion ____________ 4.

5. sense of movement of self or surroundings; dizziness ____________ 5.

6. chronic disorder with abnormality of brain function but without apparent changes in nerve tissues (falling sickness) ____________ 6.

7. an irregularity in the curvature of the lens or cornea of the eye resulting in faulty vision ____________ 7.

8. destruction of brain tissue as a result of hemorrhage from cerebral blood vessels ____________ 8.

9. condition in which the lens becomes opaque or white ____________ 9.

10. an acute viral disease that affects the brain and spinal cord; the virus may destroy motor nerve cells in the spinal cord, causing paralysis ____________ 10.

11. inflammation of the membranes covering the brain and spinal cord ____________ 11.

12. inflammation of the conjuctiva of the eye ____________ 12.

13. inflammation of the middle ear ______________ 13.

14. type of deafness caused by bone changes that prevent normal vibration of the stapes ______________ 14.

15. nausea, vomiting, and dizziness induced by irregular or rhythmic movements such as car sickness or seasickness ______________ 15.

16. impaired vision or blindness as a result of excessive intraocular pressure ______________ 16.

17. chronic, slowly progressive disease of the central nervous system due to degeneration of axons ______________ 17.

18. congenital brain disorder characterized by diverse disorders of muscles varying from weakness to complete paralysis ______________ 18.

19. defect in vision in which the light rays focus in front of the retina ______________ 19.

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper. Suggested topics are:

- Phylogenetic Development of the Brain and Nervous System
- Inheritance of Central Nervous System Diseases
- Corneal Transplants
- Current Uses of Hearing Devices
- New Methods of Controlling Old Diseases: Epilepsy, Parkinson's, Chorea, Multiple Sclerosis
- Uses of Computerized Transaxial Tomography
- Modern Miracle Workers—Dr. Jonas Salk, Dr. Albert Sabin, Others
- Identification of Mental Health Problems

Topics should reflect student interest. The topic could provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. m
2. u
3. f
4. p
5. a
6. c
7. s
8. v
9. r
10. q
11. t
12. k
13. b
14. n
15. i
16. g
17. e
18. w
19. l
20. h

Suggested Activity #2: Reflex Activity

1. The leg and foot are extended.
2. The foot extends.
3. gagging and perhaps coughing
4. increased size of pupil in eye opposite to side of neck stimulated

Suggested Activity #3: Identification of Parts of the Brain

Students should label the parts of the brain correctly (see figs. 1 and 2).

Suggested Activity #4: Identification of Parts of a Neuron

Students should label the parts of the neuron correctly (see fig. 4B).

Suggested Activity #5: Identification of Parts of the Ear

Students should label the parts of the ear correctly (see fig. 7).

Suggested Activity #6: Identification of Parts of the Eye

Students should label the parts of the eye correctly (see fig. 9).

Suggested Activity #7: Identification of Diseases and Disorders of the Nervous System and Special Senses

1. encephalitis
2. hyperopia (hypermetropia)
3. tinnitus
4. paralysis
5. vertigo
6. epilepsy
7. astigmatism
8. cerebrovascular accident
9. cataract
10. poliomyelitis
11. meningitis
12. conjunctivitis
13. otitis media
14. otosclerosis
15. motion sickness
16. glaucoma
17. multiple sclerosis
18. cerebral palsy
19. myopia

Suggested Activity #8: Research Paper

Evaluated by the instructor.

TEST / UNIT 7

The Nervous System and Special Senses

I. Write the term that is identified or defined in the phrases below in the blank space at the right. Choose the correct term from the list below.

effector
extrinsic
fissure
ganglion
lacrimal
meatus
melanin
motor neuron
neuroglia
ossicle
reflex
refract
sulci
synapse

1. small bone ____________ 1.

2. coming from without ____________ 2.

3. pertaining to tears ____________ 3.

4. an involuntary response to a stimulus ____________ 4.

5. nerve cells found in the brain that have supporting or repair functions ____________ 5.

6. neurons that transmit impulses away from the brain and spinal cord ____________ 6.

7. muscle or gland that responds to stimulation in a reflex arc ____________ 7.

8. minute space between the dendrite of one neuron and the axon of another ____________ 8.

9. mass of nerve tissue outside the spinal cord or brain ____________ 9.

10. to bend; to deflect ____________ 10.

II. To which of the main parts of the nervous system do each of the following belong? Write either **central** or **peripheral** in the blank space after each part.

1. ganglion ____________ 1.

2. spinal cord ____________ 2.

3. spinal nerves ____________ 3.

4. cranial nerves ____________ 4.

5. brain ____________ 5.

6. autonomic nervous system ____________ 6.

III. Complete the following statements by adding the word or words that best complete the meaning.

1. The largest part of the brain is the ______________ 1.

2. The functions of the cerebrum are broadly divided into sensory, association, and ______________ areas. ______________ 2.

3. The brain part that transmits messages from the spinal cord to the pons is the ______________ 3.

4. The brain and spinal cord are surrounded and protected by three layers of tissue called the ______________ 4.

5. The involuntary or automatic functions of the body are controlled by the ______________ nervous system. ______________ 5.

6. Two kinds of nerve cells are neuroglia and ______________ 6.

7. The short branches of a neuron that receive stimuli are called ______________ 7.

8. The sheath that covers myelin and is essential for the regeneration of cut or injured nerve tissue is ______________ 8.

9. Three types of neurons are interneurons, motor (efferent), and ______________ neurons. ______________ 9.

10. The kind of neuroglia that phagocytize microbes and cellular debris are ______________ 10.

IV. The following paragraph traces the path of sound waves through the parts of the ear, and identifies parts of the ear. Note the numbered blank spaces in the paragraph. Write the name of the part indicated in the blanks below the paragraph.

Sound waves enter the external auditory canal. They strike the ___(1)___, which is between the outer and middle ear, and cause it to vibrate. This vibratory motion causes the ossicles to move. This, in turn, causes the ___(2)___ to vibrate. This vibration then causes pressure waves in the liquid of the ___(3)___. The nerve centers here are stimulated by the waves and transmit impulses to the hearing center of the brain by the ___(4)___ nerve. The tube that connects the middle ear to the nasopharynx is the ___(5)___. The utricle, the saccule, and the ___(6)___ are all concerned with equilibrium.

______________________________ 1.

______________________________ 2.

______________________________ 3.

______________________________ 4.

______________________________ 5.

______________________________ 6.

V. Name in order the structures of the eye through which light passes as it enters the eye through the cornea until it reaches the retina. Write an "R" after each of these that is refractive.

1. cornea (R)
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. retina

Name the part of the eye that performs each of the following functions:

7. conducts nerve impulses from the retina to the brain ______________ 7.
8. controls size of pupil ______________ 8.
9. controls shape of lens ______________ 9.
10. receptors that are sensitive to dim light and function in night vision ______________ 10.
11. receptors that sense colors and shapes ______________ 11.
12. produces tears ______________ 12.

VI. Answer the following questions in as few words as possible to retain their meaning.

1. Where are olfactory sense organs located?

______________________________________ 1.

2. What is the role of the mucous membrane in determining odors?

______________________________________ 2.

3. Why is pain considered a defense mechanism?

______________________________________ 3.

4. What is phantom pain?

______________________________________ 4.

VII. Trace the results of an impulse through a reflex arc. Name the parts in order.

______________________ 1.

______________________ 2.

______________________ 3.

______________________ 4.

______________________ 5.

______________________ 6.

VIII. Label the numbered parts of the diagram of the brain. Please do not write on the diagram.

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________
7. ______________
8. ______________
9. ______________
10. ______________
11. ______________
12. ______________

IX. Label the numbered parts of the diagram of the eye.

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________
7. ______________
8. ______________
9. ______________
10. ______________
11. ______________
12. ______________

X. Match the following diseases with the matching descriptive phrase using letter answers.

____ 1. inflammation of the middle ear

____ 2. lens becomes opaque or white

____ 3. sense of movement of self or surroundings; dizziness

____ 4. infection of the brain

____ 5. defect in vision in which light rays focus in front of the retina (nearsightedness)

____ 6. destruction of brain tissue as a result of hemorrhage from cerebral blood vessels

a. astigmatism

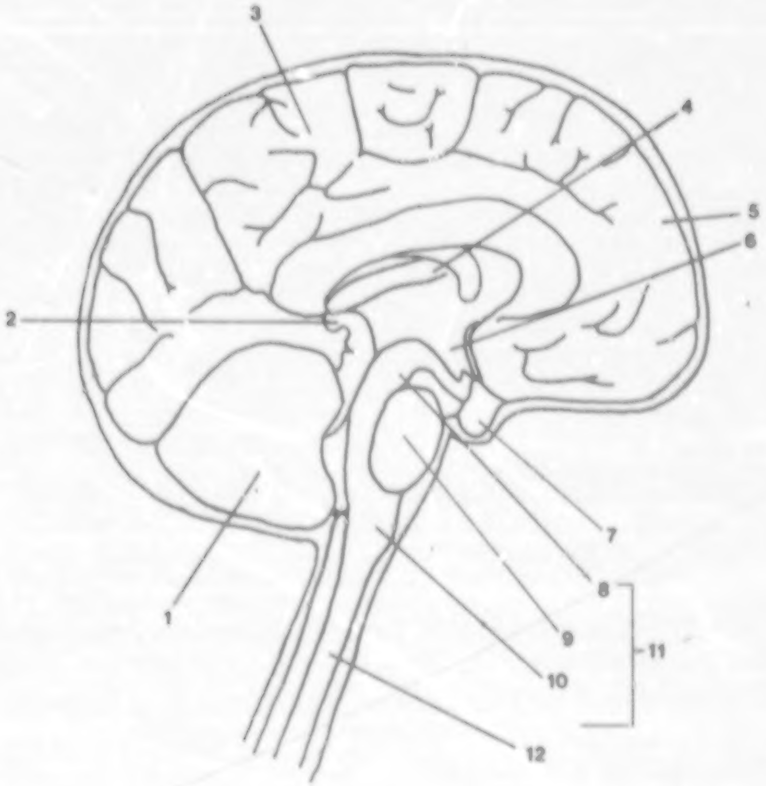
b. cataract

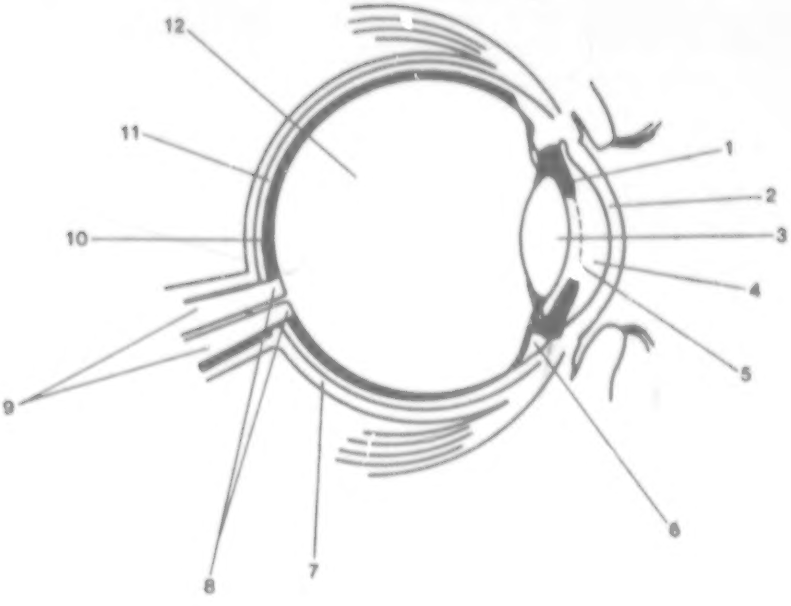
c. cerebral palsy

d. cerebrovascular accident (CVA)

e. encephalitis

f. hyperopia (hypermetropia)


3
4
5
6
2
7
8
9
11
10
1
12


12
11
1
2
10
3
4
5
9
6
8
7

_____ 7. temporary or permanent loss of function, especially loss of sensation or voluntary motion

_____ 8. congenital brain disorder, characterized by diverse disorders of muscles varying from weakness to complete paralysis

_____ 9. type of deafness caused by bone changes that prevent normal vibration of the stapes

_____ 10. inflammation of the membranes covering the brain and spinal cord

g. meningitis

h. myopia

i. otitis media

j. otosclerosis

k. paralysis

l. vertigo

ANSWERS TO TEST

I.
1. ossicle
2. extrinsic
3. lacrimal
4. reflex
5. neuroglia
6. motor neuron
7. effectors
8. synapse
9. ganglion
10. refract

II.
1. peripheral
2. central
3. peripheral
4. peripheral
5. central
6. peripheral

III.
1. cerebrum
2. motor
3. medulla
4. meninges
5. autonomic
6. neurons
7. dendrites
8. neurilemma
9. sensory (afferent)
10. microglia

IV.
1. eardrum (tympanic membrane)
2. membrane covering the oval window
3. cochlea
4. auditory
5. eustachian
6. semicircular canals

V.
1. cornea (R)
2. pupil
3. aqueous humor (R)
4. lens (R)
5. vitreous humor (R)
6. retina
7. optic nerve
8. iris
9. ciliary muscle
10. rods
11. cones
12. lacrimal glands

VI.
1. in the upper nasal cavity
2. The mucus dissolves gaseous particles.
3. It warns the body of danger.
4. The patient senses pain in a removed limb because of stimulation of sensory nerves that previously received stimuli from amputated limb.

VII.
1. sensory neuron (receptor)
2. synapse
3. interneuron
4. synapse
5. motor neuron
6. effector (muscle or gland)

VIII. 1. cerebellum
2. pineal gland
3. cerebrum
4. thalamus
5. diencephalon
6. hypothalamus
7. pituitary gland
8. midbrain
9. pons
10. brain stem
11. medulla
12. spinal cord

IX. 1. iris
2. cornea
3. lens
4. aqueous humor
5. pupil
6. ciliary muscle
7. sclera
8. blind spot
9. optic nerve
10. retina
11. choroid
12. vitreous body

X. 1. i
2. b
3. l
4. e
5. h
6. d
7. k
8. c
9. j
10. g

Unit 8

The Urinary System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the urinary system;
2. identify the parts of the urinary system;
3. give the function of each part of the urinary system;
4. give the steps in the formation of urine;
5. list the characteristics of urine;
6. discuss dialysis and transplants; and
7. identify diseases and disorders of the urinary system.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"
This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification of Organs of the Urinary System"
Study of the diagram and model and identification of the parts will enhance the descriptions given in the text and help the student to understand the function of the various parts.

Suggested Activity #3: "Identification of the Inside Structures of the Kidney"
Study of the diagram and model will help the student to identify the parts and understand their function.

Suggested Activity #4: "Identification of Parts of a Renal Corpuscle"
Study of the diagram will help the student understand the function of the parts and their relation to each other.

Suggested Activity #5: "Urine Formation"
The questions in this exercise are designed to help the student to organize information about the process of urine formation.

Suggested Activity #6: "Demonstration of Dialysis"
This experiment will help the student to understand kidney function as well as the functioning of dialysis machines. The principles of osmosis and diffusion should be reviewed before performing the experiment.

Suggested Activity #7: "Identification of Diseases and Abnormalities of the Urinary System"

This exercise provides practice in recognition of the correct terms to match definitions. Reading the definitions for identification reinforces recognition.

Suggested Activity #8: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 8

Review Questions

1. What are the three main functions of the urinary system?
2. Name the parts of the urinary system.
3. Where are the kidneys located?
4. Name the two main divisions of the interior of the kidney.
5. How is urine moved through the ureters to the urinary bladder?
6. What are the two functions of the urinary bladder?
7. What are the factors that influence the amount of urine excreted?
8. Explain why urination is voluntary in adults and involuntary in children.
9. Name two causes of enuresis.
10. What is the location of the urethra?
11. Name the parts of a renal corpuscle.
12. From what capillaries do water and solutes pass from the blood to the nephron?
13. What is the glomerular filtrate?
14. From what part of the nephron is most of the water and solutes returned to the blood?
15. Where does the remaining filtrate go?
16. Which solute leaves the loop of Henle by active transport?
17. What materials in the remaining filtrate are removed to the capillaries from the distal tubule?
18. Where in the nephron does the secretion of hydrogen ions and ammonia that regulate the acid-base concentration of urine take place?
19. Where in the kidney does urine from the nephrons collect?
20. List the three processes in urine formation carried on in the nephrons.
21. List the inorganic and organic wastes that may be found in normal urine.
22. What is **hemodialysis**?
23. What is a kidney transplant?
24. What is tissue rejection?

ANSWERS TO REVIEW QUESTIONS

1. (1) to excrete waste products from the blood
   (2) to regulate the water balance of the body
   (3) to regulate the acid-base balance of the body
2. kidneys, ureters, urinary bladder, and urethra
3. They are located on each side of the spinal column at the level of the twelfth thoracic and first three lumbar vertebrae. They are on the posterior abdominal wall behind the peritoneum.
4. (1) cortex
   (2) medulla
5. by peristalsis
6. (1) to serve as a reservoir for urine
   (2) to expel urine from the body through the urethra
7. fluid intake, diet, activity, environmental and body temperature, age, and blood pressure
8. In children, urination occurs reflexively; in adults, urination is controlled by the brain.
9. (1) local irritation of the bladder and urethra
   (2) emotional instability
10. It extends from the anterior part of the urinary bladder to the outside of the body.
11. glomerulus and Bowman's capsule
12. capillaries of the glomeruli
13. water and solutes from the glomerular capillaries
14. proximal tubule
15. to the loop of Henle
16. sodium chloride
17. some water and sodium ions
18. in the distal tubule
19. in the pelvis of the kidney
20. (1) filtration
    (2) reabsorption
    (3) secretion
21. **organic**—urea, uric acid, ammonia, and creatinine
    inorganic—sodium chloride, potassium chloride, calcium, magnesium and phosphorus
22. It is a procedure for the mechanical removal of waste materials from the blood. It is used by patients whose kidneys are defective.
23. It is when a kidney from a healthy donor is transplanted into the body of a patient with critical kidney disease.
24. When the body responds to a transplant as foreign protein and produces antibodies to destroy the transplant, this is called "tissue rejection."

Suggested Activity #1: Practice with New Terms UNIT 8

Choose the correct term for the following definitions from the list below:

anuria
calculus
dialysis
enuresis
glycosuria
hematuria
incontinence
meatus
micturition
nephron
nitrogenous waste
peristalsis
semen
sphincter
transplant
urology

1. the study of the urinary system ______________ 1.

2. lack of voluntary control over urination or defecation ______________ 2.

3. unit of the kidney; Bowman's capsule and tubules ______________ 3.

4. failure of the kidneys to secrete urine ______________ 4.

5. transfer of tissue or organ from one person to another ______________ 5.

6. stone formed within the body, made up of mineral salts ______________ 6.

7. circular muscle surrounding an opening; closes the opening by muscle contraction ______________ 7.

8. passage or opening; the external opening of the urethra ______________ 8.

9. diffusion of a dissolved substance through a semipermeable membrane (diffusion of blood across a semipermeable membrane to remove toxic materials in cases of impaired kidney function) ______________ 9.

10. urination ______________ 10.

11. progressive wavelike movement that occurs involuntarily in hollow tubes of the body (as in the digestive tract and ureters) ______________ 11.

12. involuntary urination in persons over 3 years of age (bedwetting) ______________ 12.

13. secretion of male sex glands; contains sperm cells ______________ 13.

14. presence of glucose in urine ______________ 14.

15. waste products removed in the urine ______________ 15.

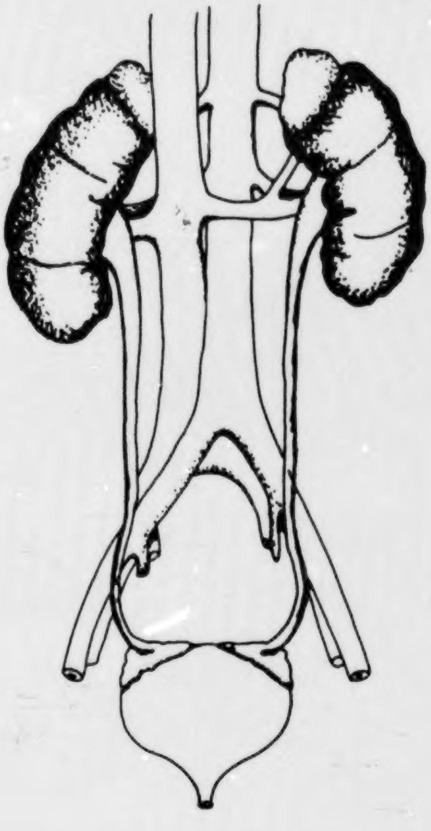
16. presence of blood in urine ______________ 16.

Objective: To identify the organs of the urinary system

Materials: Anatomical model showing organs of the urinary system, if available
Diagram (same as figure 1, but without labels)

Procedure: Review names of organs of the urinary system on figure 1. Then label parts on the diagram without using references.

Results: Students should be able to label the diagram correctly.

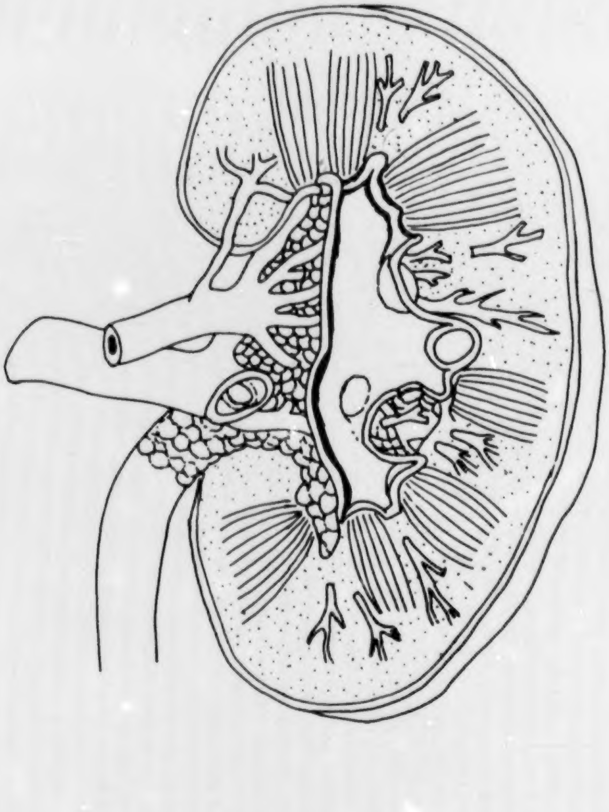


Objective: To identify the inside structures of the kidney

Materials: Model of the kidney showing inside structure (if available)
Figure 2 and diagram

Procedure: Review the internal structure of the kidney and identify parts, using the model and figure 2. Then label the diagram without using references.

Results: Students should be able to label the diagram correctly.



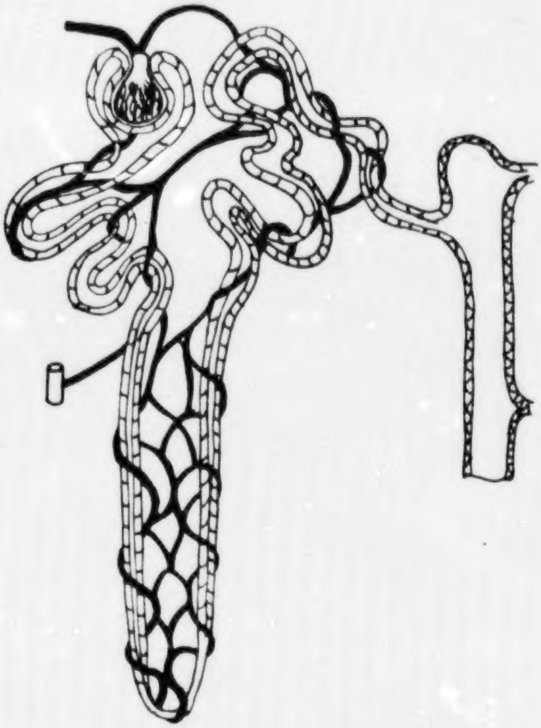
Suggested Activity #4: Identification of Parts of a Renal Corpuscle **UNIT 8**

Objective: To identify the parts of a renal corpuscle

Materials: Figure 3 and diagram

Procedure: Review the parts of a renal corpuscle on figure 3. Then label the diagram without using references.

Results: Students should be able to label the diagram correctly.



Complete the following statements by writing the correct word(s) in the blank on the right.

1. Blood flows to the kidney from the aorta by means of the ______________ 1.

2. The network of capillaries that fits into the cuplike shape of Bowman's capsule is a/an ________________. ______________ 2.

3. Water and solutes pass through the walls of the ________________ to Bowman's capsule. ______________ 3.

4. Large particles such as blood cells and ____________ molecules do not normally pass through the capillary walls. ______________ 4.

5. In which area of the nephron is most of the water, electrolytes, and nutrients returned to the capillaries? ______________ 5.

6. In the loop of Henle, ________________ moves from the tubule to the interstitial cells of the medulla. ______________ 6.

7. The hormone that controls the amount of water reabsorbed from the distal tubule and collecting tubule is _________. ______________ 7.

8. Aldosterone helps regulate the body's water balance and the reabsorption of sodium and __________________. ______________ 8.

9. Hydrogen ions and ammonia are secreted in the ________________ tubule. ______________ 9.

10. The blood from the kidney returns by means of the ________________. ______________ 10.

11. Large collecting tubules empty into the ______________ in the pelvis of the kidney. ______________ 11.

12. Waste solutes and water removed from the blood by the kidneys form ________________. ______________ 12.

Suggested Activity #6: Demonstration of Dialysis

Objective: To demonstrate a selectively permeable membrane

Materials:

Starch suspension
80% glucose solution
Iodine solution
Glass droppers
Beakers
Benedict's solution
Dialysis bags
String

Procedure:

1. Pre-wet the dialysis bag in a beaker of distilled water.
2. Change water at intervals for one hour.
3. Tie end of bag to carefully avoid any leak.
4. Rub the untied end between thumb and forefinger to open bag.
5. Fill bag with glucose solution and starch suspension. Remove air bubbles.
6. Rinse outside of bag to remove any spilled solution.
7. Fill bag with string, leaving several inches of string to maneuver bag.
8. Place the bag in a beaker of distilled water.
9. Mark the water level.
10. After 20 minutes, remove a dropper full of water from the beaker. Note that water level in the beaker has lowered.
11. Test the water in the beaker for the presence of glucose using Benedict's solution.
12. Place about 1 ml of fluid from inside the dialysis tube in a test tube.
13. Add 3 drops of iodine solution. Note the characteristic blue-black color that indicates the presence of starch.
14. Clean, rinse, and store the equipment.

Results:

1. Explain why glucose molecules were present in the water in the beaker around the dialysis tubing.
2. Why did the water level in the beaker become lower?
3. Why was starch not present in the water?
4. What structure in the nephron compares to the dialyzing membrane?
5. In this experiment, glucose and starch molecules were used. What kinds of molecules are moved across cell membranes in the kidney?
6. What physical force caused the movement of water and glucose molecules in this exercise?
7. Name the forces that move molecules through the cell membranes of the renal corpuscle.
8. Why is dialysis useful to patients whose kidneys do not function properly?

Suggested Activity #7: Identification of Diseases and Abnormalities of the Urinary System

Choose the term that is identified in the descriptions. Use letter answers.

_____ 1. condition in which body tissues contain an excessive amount of tissue fluid; swelling
(a) pyelitis (b) urethritis (c) edema (d) cystitis

_____ 2. inflammation of the urethra
(a) urethritis (b) cystitis (c) pyelitis (d) dysuria

_____ 3. less than normal amount of urine formed
(a) uremia (b) oliguria (c) dysuria (d) nephritis

_____ 4. severe inflammation of the kidneys
(a) pyelitis (b) edema (c) nephritis (d) polyuria

_____ 5. excessive amount of urine formed
(a) polyuria (b) oliguria (c) dysuria (d) nephritis

_____ 6. inflammation of the pelvis of the kidney
(a) cystitis (b) pyelitis (c) edema (d) polycystic disease

_____ 7. condition in which nitrogenous wastes normally excreted by the kidney are retained in the blood
(a) edema (b) polyuria (c) polycystic disease (d) uremia

_____ 8. condition in which the kidney contains many cystlike dilations as a result of deformity of nephrons; inherited disorder
(a) polycystic disease (b) oliguria (c) polyuria (d) edema

_____ 9. inflammation of the bladder
(a) polyuria (b) uremia (c) dysuria (d) cystitis

_____ 10. painful urination; sympton of various disease conditions
(a) oliguria (b) uremia (c) dysuria (d) urethritis

Suggested Activity #8: Research Paper

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper.

Suggested topics are:

- Kidney Transplants
- Kidney Dialysis (This topic lends itself to demonstration.)
- Urinalysis as a Diagnostic Tool (Demonstrations of Procedures)
- Methods of Dissolving Kidney Stones in Vivo

Topics should reflect student interest. The topic could provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. urology
2. incontinence
3. nephron
4. anuria
5. transplant
6. calculi
7. sphincter
8. meatus
9. dialysis
10. micturition
11. peristalsis
12. enuresis
13. semen
14. glycosuria
15. nitrogenous waste
16. hematuria

Suggested Activity #2: Identification of Organs of the Urinary System

See figure 1 for correct labels.

Suggested Activity #3: Identification of the Inside Structures of the Kidney

See figure 2 for correct labels.

Suggested Activity #4: Identification of Parts of a Renal Corpuscle

See figure 3 for correct labels.

Suggested Activity #5: Urine Formation

1. renal artery
2. glomerulus
3. glomeruli
4. protein
5. convoluted tubule
6. sodium chloride
7. antidiuretic hormone (ADH)
8. potassium
9. distal
10. renal vein
11. calyx
12. urine

Suggested Activity #6: Demonstration of Dialysis

1. Glucose molecules passed through the dialysis membrane.
2. Water moved from the beaker through the semipermeable dialysis membrane into the dialysis tubing. Water molecules always move from a region of higher concentration of water molecules to a region of lower concentration of water molecules. This is diffusion or osmosis.
3. Starch molecules did not move across the dialysis membrane.
4. the capillary walls of the glomeruli and the parietal walls of Bowman's capsule and walls of tubules
5. water, electrolytes, food molecules, and minerals
6. diffusion or osmosis
7. active transport, passive transport, diffusion, and osmosis
8. The process of dialysis removes waste materials from the blood.

Suggested Activity #7: Identification of Diseases and Abnormalities of the Urinary System

1. c
2. a
3. b
4. c
5. a
6. b
7. d
8. a
9. d
10. c

Suggested Activity #8: Research Paper

Evaluated by the instructor.

TEST / UNIT 8

The Urinary System

I. Match the following terms with the phrases using letter answers.

_____ 1. involuntary urination in persons over 3 years of age (bedwetting)

_____ 2. urination

_____ 3. secretion of male sex glands; contains sperm cells

_____ 4. waste products removed in urine

_____ 5. a unit of the kidney; Bowman's capsule and tubules

_____ 6. failure of the kidneys to secrete urine

_____ 7. diffusion of a dissolved substance through a semipermeable membrane

_____ 8. the study of the urinary system; branch of medicine that treats diseases of the urinary system

_____ 9. the presence of blood in the urine

_____ 10. a passage or opening; the external opening of the urethra

_____ 11. presence of glucose in the urine

_____ 12. stone of mineral salts formed within the body

_____ 13. circular muscle surrounding an opening; closes opening by muscle contraction

_____ 14. transfer of tissue or organ from one person to another

_____ 15. lack of voluntary control over urination or defecation

a. anuria
b. calculus
c. dialysis
d. enuresis
e. glycosuria
f. hematuria
g. incontinence
h. meatus
i. micturition
j. nephron
k. nitrogenous waste
l. peristalsis
m. semen
n. sphincter
o. transplant
p. urology

II. Complete the following statements.

1. The interior of the kidney is divided into the inner portion (the medulla) and the outer portion (the _______________). _______________ 1.

2. The functions of the urinary bladder are to expel urine from the body and _______________ 2.

3. Both voluntary and _______________ nerve impulses occur to bring about urination. _______________ 3.

4. The three segments of a nephron are the proximal tubule, the loop of Henle, and the ____________ 4.

5. Inflammation of the bladder is ____________ 5.

6. Inflammation of the pelvis of the kidney is ____________ 6.

7. The condition in which body tissues contain an excessive amount of body fluid (and swelling occurs) is ____________ 7.

8. The procedure for mechanically removing waste from the blood is ____________ 8.

9. A renal corpuscle is made up of Bowman's capsule and a(an) ____________ 9.

10. The parts of the urinary system are the kidneys, urinary bladder, ureters, and ____________ 10.

III. List three functions of the urinary system.

1. ____

2. ____

3. ____

IV. Give the following information about urine.

1. color: ____

2. reaction: ____

3. water content: ____

4. 3 organic solutes: ____

5. 3 inorganic solutes: ____

6. 6 abnormal constituents: ____

____

V. Answer the following questions briefly and with incomplete sentences.

1. From what part of the nephron are most water and solutes returned to the blood?

2. Why do blood cells and protein molecules not leave the glomerular capillaries?

3. Where in the nephron are hydrogen ions and ammonia secreted?

4. Why are these important?

5. Where does urine from the nephrons collect prior to entry into the ureters?

VI. List the three processes by which urine is formed in the nephrons.

1. ____________________

2. ____________________

3. ____________________

VII. Name the diseases or conditions described using the terms listed.

cystitis
dysuria
edema
nephritis

oliguria
polycystic disease
polyuria

pyelitis
uremia
urethritis

1. inflammation of the urethra ______________ 1.

2. painful urination ______________ 2.

3. less than the normal amount of urine formed ______________ 3.

4. severe inflammation of the kidneys ______________ 4.

5. condition in which nitrogenous wastes normally excreted by the kidney are retained in the blood ______________ 5.

ANSWERS TO TEST

I.
1. d
2. i
3. m
4. k
5. j
6. a
7. c
8. p
9. f
10. h
11. e
12. b
13. n
14. o
15. g

II.
1. cortex
2. store urine (reservoir)
3. involuntary
4. distal tubule
5. cystitis
6. pyelitis
7. edema
8. hemodialysis
9. glomerulus
10. urethra

III.
1. to excrete waste products from the blood
2. to regulate the water balance of the body
3. to regulate the acid-base balance of the body

IV.
1. yellow-amber
2. slightly acid
3. about 95 percent
4. Any three: urea, uric acid, ammonia, creatinine
5. Any three: sodium chloride, potassium chloride, calcium, magnesium, phosphorus
6. Any six: glucose, protein, acetone, bile, urobilin, blood cells, bacteria, crystals

V.
1. from the proximal tubule
2. because they are too large
3. in the distal tubule
4. because they regulate the acid-base concentration of urine
5. in the pelvis of the kidney

VI. In any order:
1. filtration
2. reabsorption
3. secretion

VII.
1. urethritis
2. dysuria
3. oliguria
4. nephritis
5. uremia

Unit 9

The Reproductive System

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the reproductive system;
2. identify parts of the male and female reproductive system;
3. give the functions of the reproductive parts;
4. list hormones that control activities of the reproductive organs;
5. review the sequence of events in menstruation;
6. define menarche and menopause;
7. discuss lactation;
8. identify secondary sex characteristics;
9. discuss fertilization and major events in embryonic development; and
10. recognize descriptions of diseases and disorders of the reproductive system.

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification of Parts of the Male and Female Reproductive Systems"

Study of the diagrams and model help students to locate reproductive parts and to better understand their interrelation and function.

Suggested Activity #3: "Parts of the Reproductive System and Their Functions"

This exercise provides practice for students in learning the functions of the various reproductive parts.

Suggested Activity #4: "Identification of Diseases and Disorders of the Reproductive System"

This exercise provides practice in recognition of the correct terms to match definitions. Reading the definitions for identification reinforces recognition.

Suggested Activity #5: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 9

Review Questions

1. Name the internal parts of the female reproductive system.
2. Locate and describe the ovaries.
3. About how many of the 100,000 to 400,000 ova ever mature?
4. What becomes of the other immature ova?
5. What are the two functions of the ovaries?
6. Where are the oviducts located?
7. Describe the ovarian end of the oviduct.
8. Where does fertilization usually take place?
9. How is the egg cell moved through the oviduct?
10. Describe the open passage from the female peritoneal cavity to the exterior.
11. What are two functions of the oviducts?
12. Locate and describe the uterus.
13. Identify the fundus and cervix of the uterus.
14. What are the three layers of the uterine wall?
15. What are the functions of the uterus?
16. Describe the vagina.
17. Name three functions of the vagina.
18. Name the parts of the vulva.
19. What surgical procedure may be used to avoid tearing of the perineum in childbirth?
20. What is the function of the mammary glands?
21. What two hormones stimulate the production of milk?
22. What is colostrum?
23. What is menstruation?
24. What is the menarche?
25. What is the average length of the menstrual cycle?
26. As an ovarian follicle matures, what event occurs on about the 14th day of the menstrual cycle?
27. What hormone is secreted by the ovarian follicle?
28. At what point in the menstrual cycle is the endometrium the thickest?
29. What hormone is secreted by the corpus luteum?
30. What is the corpus luteum?
31. Where is the embryo implanted?
32. Name two hormones secreted by the anterior pituitary that influence the menstrual cycle.
33. What hormone controls the development of secondary sex characteristics in females?
34. What is menopause?
35. Name two functions of the placenta.
36. Differentiate between an embryo and a fetus.
37. What are three functions of the male reproductive system?
38. Describe the testes.
39. How are hernias and the descent of the testes related?
40. Why might cryptorchidism cause sterility?
41. Where are sperm cells produced?
42. Name two functions of sperm cells.
43. What is contained in the head, and in the middle piece, of a sperm cell?
44. Locate the epididymis.
45. What are three functions of the epididymis?
46. Trace the path of the vas deferens.
47. Why does a vasectomy cause sterility even though sperm production is not affected?

48. What two ducts combine to form the ejaculatory duct?
49. Which male reproductive gland secretes the largest portion of seminal fluid?
50. Why would swelling or enlargement of the prostate gland interfere with urinary flow?
51. Name the male reproductive glands that contribute fluid to form semen.
52. What are the external male reproductive organs?
53. Why is an alkaline pH of seminal fluid important?
54. What becomes of sperm cells that remain in the seminiferous tubules?
55. What is the function of hyaluronidase found in the acrosomal cap?
56. What is the principal male sex hormone called?
57. Name two body changes in males influenced by testosterone.
58. List four male secondary sex characteristics.

ANSWERS TO REVIEW QUESTIONS

1. ovaries, oviducts, uterus, and vagina
2. They are located on either side of the uterus in the upper part of the pelvis. They are paired, almond-shaped, about 4 cm long, and weigh about 3 gm each.
3. about 300 to 400
4. They degenerate, die, and are reabsorbed.
5. (1) production of ova
   (2) production of female hormones—estrogen and progesterone
6. The oviducts lead from a point near the ovaries to the upper angles of the uterus.
7. The ovarian end of the oviduct is in contact with, but not attached to, the ovary. It is funnel-shaped with many fringelike extensions (fimbriae) that function like tentacles.
8. in the upper third of the oviduct
9. by currents set up by the motion of cilia in the lining of the oviduct, and by peristalsis of the smooth muscle layer
10. The uterine tube opens into the peritoneal cavity anteriorally. The posterior end opens into the uterus, which is continuous with the vagina. The vagina opens to the exterior.
11. (1) to provide a passageway for the ovum to move from the abdominal cavity near the ovary to the uterus
    (2) to provide a site for the fertilization of the ovum
12. The uterus is located in the pelvic cavity between the rectum and the urinary bladder. It is a small, hollow, pear-shaped muscular organ, about 7.5 cm long and 5 cm across at the widest part.
13. The fundus is the bulged upper portion between the entry of the oviducts. The cervix is the narrow, lower portion that opens into the vagina.
14. (1) the outer serous layer, or perimetrium
    (2) the middle smooth muscle layer, or myometrium
    (3) the inner mucous layer, or endometrium
15. pregnancy, labor, menstruation
16. It is a tube that extends from the cervix to the exterior of the body. It is about 10 to 15 cm long and extends at a right angle downward and forward from the cervix.
17. (1) to serve as an excretory duct for uterine secretions and menstrual flow
    (2) to serve as the lower part of the birth canal
    (3) to receive seminal fluid from the male in copulation
18. labia majora, labia minora, clitoris, Bartholin's glands, vaginal outlet, and urinary meatus
19. episiotomy
20. to secrete milk for the nourishment of newborns and young children
21. lactogenic hormone (prolactin) and oxytocin
22. a fluid secreted by the mammary glands for 2 to 3 days after delivery prior to milk production; contains immune bodies, proteins, and calories
23. cyclic uterine bleeding that normally occurs at about 28-day intervals in the absence of pregnancy, and accompanying changes in female hormone concentrations
24. initiation of the menstrual cycle at puberty
25. 28 days
26. ovulation
27. estrogens
28. in the days following ovulation until the beginning of menstruation
29. progesterone

30. body formed in the ovary following the rupture of the ovarian follicle; filled with yellow lipid
31. in the uterine lining
32. (1) FSH (follicle-stimulating hormone)
    (2) LH (luteinizing hormone)
33. estrogens
34. the cessation of the menstrual cycle
35. (1) exchange of food, gases, and wastes between mother and baby
    (2) acts as a barrier against bacteria between mother and baby
36. An **embryo** refers to a child from the second through the eighth week of uterine life. A **fetus** is a child from the third month of uterine life to birth.
37. (1) to product spermatozoa
    (2) to secrete male sex hormones
    (3) to introduce sperm cells into female vagina
38. paired oval organs about 4 to 5 mm long and weighing about 10 to 15 gm each
39. The testes of the male fetus descend from the abdominal cavity through the inguinal canal to the scrotum about two months before birth. If the inguinal area remains weakened, part of an intestine may push through the weakened spot. This is called a hernia.
40. The higher temperature in the abdomen inhibits sperm production.
41. in the spermatogonia of the testes
42. (1) to combine with the ovum in fertilization
    (2) to contribute genetic material to the zygote
43. head—nuclear material containing genetic material
    middle piece—mitochondria and centrosome
44. lies along the top and sides of the testes
45. (1) to serve as a duct for sperm cells from the testes to the vas deferens
    (2) to store sperm cells
    (3) to secrete a fraction of the seminal fluid
46. It leads from the junction with the epididymis upward into the abdominal cavity across the top and down the posterior surface of the urinary bladder to join the duct of the seminal vesicle.
47. Sperm cells are unable to pass through the vas deferens.
48. (1) the end of the vas deferens
    (2) the ducts of the seminal vesicles
49. the prostate
50. It could constrict the ureter because it surrounds it.
51. epididymis, vas deferens, seminal vesicles, prostate gland, and Cowper's glands
52. the scrotum and penis
53. Sperm cells require an alkaline pH for optimum locomotion.
54. They degenerate and are absorbed.
55. It liquifies the intercellular material that encases the ovum.
56. testosterone
57. (1) development of male sex organs
    (2) sperm cell production
58. (1) growth of bones and muscles characteristic of males
    (2) body height and size
    (3) facial and body hair patterns
    (4) voice tone

Suggested Activity #1: Practice with New Terms UNIT 9

Match the following terms with the phrases using letter answers.

____ 1. the process by which offspring are produced

____ 2. beginning of menstruation

____ 3. cell produced by the union of an egg cell with a sperm cell

____ 4. sexual intercourse

____ 5. periodic discharge of ovum from ovary

____ 6. male reproductive cell; sperm cell

____ 7. cessation of menstruation

____ 8. secretion of a ductless gland that regulates the function of other organs

____ 9. secretion of male reproductive organs containing sperm cells and secretions from accessory reproductive glands

____ 10. surgical removal of the uterus

____ 11. in delivery of a child, some part other than the head is first to emerge from the birth canal, most commonly the buttocks or foot

____ 12. early or developing stage of any organism, in humans, the 2nd through the 8th week of uterine life

____ 13. cyclic uterine bleeding that normally occurs at about 4-week intervals in the absence of pregnancy; controlled by hormones

____ 14. the union of an ovum with a sperm cell to produce a zygote

____ 15. act of giving birth to young

____ 16. female reproductive cell; an egg cell

____ 17. latter stages in developing child in uterus from about the third month of pregnancy to birth

____ 18. reproductive organs

____ 19. the time that the embryo or fetus remains in the uterus (280 days)

a. breech presentation
b. cesarean section
c. copulation
d. embryo
e. episiotomy
f. fertilization
g. fetus
h. hormone
i. hysterectomy
j. genitalia (genitals)
k. gestation
l. menarche
m. menopause
n. menstruation
o. ovulation
p. ovum
q. parturition
r. reproduction
s. semen
t. spermatazoon
u. vasectomy
v. zygote

_____ 20. removal of a fetus by means of incision into the uterus, usually by way of the abdominal wall

_____ 21. incision of perineum at the end of the second stage of labor to avoid laceration of perineum and to facilitate delivery

_____ 22. removal of a segment of the vas deferens to produce sterility in males

Suggested Activity #2: Identification of Parts of the Male and Female Reproductive Systems

Objective: To identify the parts of the male and female reproductive systems

Materials: Diagram of the male reproductive system (fig. 4)
Diagram of the female reproductive system (fig. 1)
Human torso models or charts, if available

Procedure:

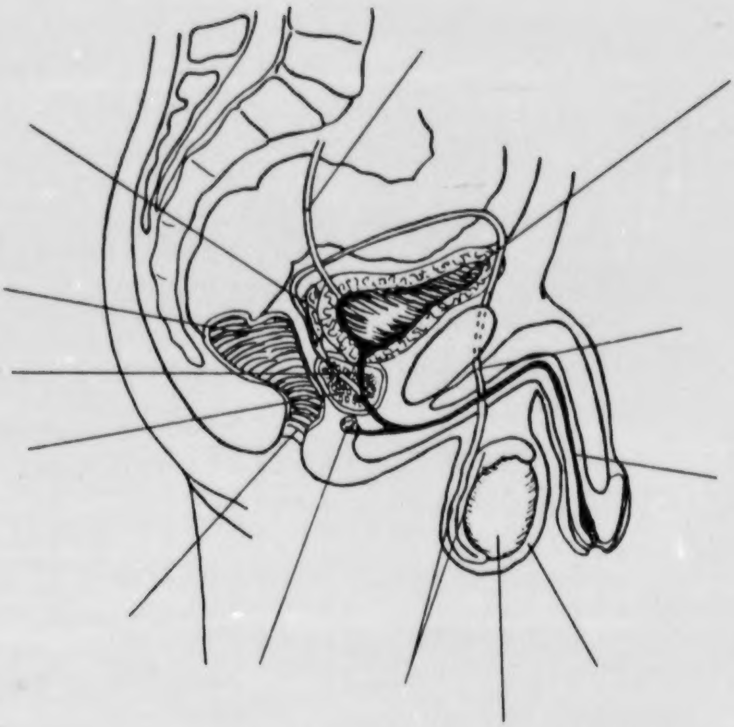
1. Using the model, charts, and/or diagrams, note the location of the parts of the male and female reproductive systems.

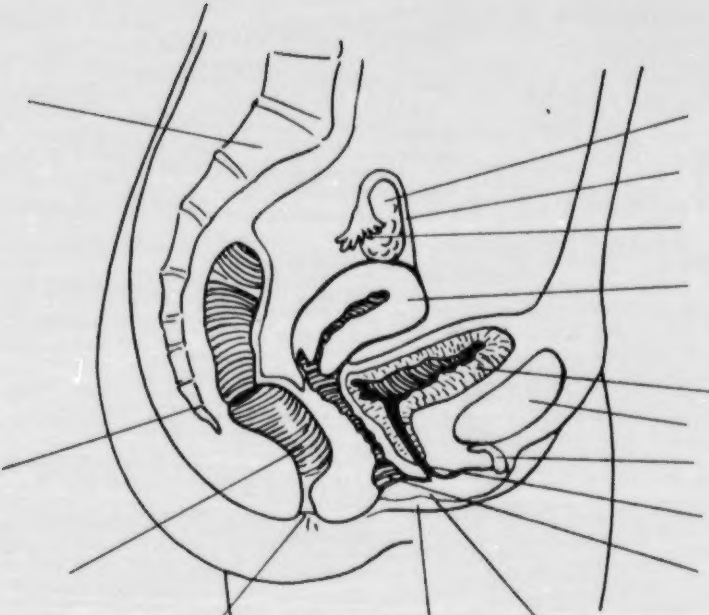
2. Label the following parts of the male reproductive system on the diagram without using references:

   testis
   scrotum
   urethra
   vas deferens
   bulbourethral gland
   urinary bladder
   seminal vesicle
   ejaculatory duct
   prostate

3. Label the following parts of the female reproductive system on the diagram without using references.

   labia majora
   labia minora
   vagina
   urethra
   clitoris
   pubic symphysis
   urinary bladder
   uterus
   fimbriae
   uterine tube (oviduct)
   ovary





Suggested Activity #3: Parts of the Reproductive System and Their Functions

Objective: To identify the various parts of the reproductive system and their functions

Procedure: Descriptions and functions of the various parts of the reproductive system are given below. Using the lesson as a reference, identify the parts described.

1. Glands that secrete a lubricating fluid, located on either side of the vaginal opening. Their ducts open into the labia minora. ______________ 1.

2. Specialized fold of skin that contains the testes. ______________ 2.

3. Very small tightly coiled tube that lies along the top and sides of each testis; leads to the vas deferens. ______________ 3.

4. The pelvic floor, a muscular area between the thighs and buttocks in both males and females. ______________ 4.

5. Thin, yellowish, fluid secreted by the mammary glands which contains a high concentration of immune bodies, proteins, and calories—precedes true lactation. ______________ 5.

6. Collective term for the external genitalia of the female reproductive system. ______________ 6.

7. Male reproductive organs that produce sperm cells and male hormones. ______________ 7.

8. Gland that surrounds the urethra and secretes most of the seminal fluid. ______________ 8.

9. Fringelike extensions from the abdominal openings of the oviducts, which move to draw ova into oviducts. ______________ 9.

10. Tube extending from the cervix to the exterior, excretory duct for uterine secretions and menstrual flow. ______________ 10.

11. Male organ by which sperm cells are introduced into the female vagina. ______________ 11.

12. The organs that produce ova and female hormones. ______________ 12.

13. The organ that contains and nourishes the developing embryo. ______________ 13.

14. Ducts that transport the ova from the body cavity near the ovaries to the uterus. ______________ 14.

15. Ducts in which fertilization of an egg cell by a sperm cell normally takes place. ____________ 15.

16. The structure that functions in the exchange of food, gases, and wastes between mother and baby. ____________ 16.

17. The duct that leads from the epididymis to join the duct of the seminal vesicle, then to join the ejaculatory duct. ____________ 17.

18. The part of the sperm cell that produces hyaluronidase. ____________ 18.

19. Pair of small pea-shaped glands just below the prostate; secrete an alkaline component of semen. ____________ 19.

20. Reproductive cells produced in the testes. ____________ 20.

Suggested Activity #4: Identification of Diseases and Disorders of the Reproductive System

Objective: To become familiar with the names and descriptions of common diseases and disorders of the reproductive system

Procedure: The following are descriptions of diseases and disorders of the reproductive system. Write the correct disease from the four choices offered in each question, using your lesson as a reference.

1. inability to reproduce; inability to form sperm cells or ova
(orchitis) (abortion) (puerperal fever) (sterility) ______________ 1.

2. an infectious disease transmitted primarily by sexual contact
(venereal disease) (dysmenorrhea) (orchitis) (inguinal hernia) ______________ 2.

3. a venereal disease occurring most often in homosexual males; cause, cure, and treatment unknown, but patient's immune system does not function normally
(AIDS—acquired immune deficiency syndrome) (syphilis) (tumor) (genital herpes) ______________ 3.

4. inflammation of the oviducts
(ectopic pregnancy) (salpingitis) (orchitis) (dysmenorrhea) ______________ 4.

5. an infectious venereal disease that affects the urogenital tract; caused by a bacterium (**Neisseria gonorrhoeae**); characterized by a purulent, urethral discharge; most common communicable disease after the common cold
(syphilis) (genital herpes) (AIDS) (gonorrhea) ______________ 5.

6. painful menstruation
(dysmenorrhea) (salpingitis) (ectopic pregnancy) (tumor) ______________ 6.

7. any bacterial infection of the uterus, ovaries, or oviducts
(prostatitis) (pelvic inflammatory diseases, or P.I.D.) (puerperal fever) (sterility) ______________ 7.

8. loss of embryo or fetus during the first 20 weeks of pregnancy
(ectopic pregnancy) (venereal disease) (abortion) (P.I.D.) ______________ 8.

9. failure of the testes to descend from the abdominal cavity to the scrotum
(cryptorchidism) (inguinal hernia) (prostatitis) (orchitis) ______________ 9.

10. infectious venereal disease characterized by lesions which may involve any organ or tissue, caused by **Treponema pallidum**
(gonorrhea) (genital herpes) (syphilis) (cryptorchidism) ______________ 10.

Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper.

Suggested topics are:

- AIDS—Mystery Disease of the '80s
- External Human Fertilization—Case Studies
- Our National Infant Mortality Rate—Cause for Concern
- The Effects of Radiation on Fertility
- Genital Herpes
- Social Impact of Teenage Pregnancy
- Causes of Sterility
- Medical Specialties That Deal with Reproduction

Topics should reflect student interest. The topic could provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. r
2. l
3. v
4. c
5. o
6. t
7. m
8. h
9. s
10. i
11. a
12. d
13. n
14. f
15. q
16. p
17. g
18. j
19. k
20. b
21. e
22. u

Suggested Activity #2: Identification of Parts of the Male and Female Reproductive Systems

Students should label the diagrams correctly without the use of references. Use figures 1 and 4 to evaluate student answers.

Suggested Activity #3: Parts of the Reproductive System and Their Functions

1. Bartholin's glands
2. scrotum
3. epididymis
4. perineum
5. colostrum
6. vulva (pudendum)
7. testes
8. prostate
9. fimbriae
10. vagina
11. penis
12. ovaries
13. uterus
14. oviduct (uterine tube or Fallopian tube)
15. oviduct (uterine tube or Fallopian tube)
16. placenta
17. vas deferens
18. acrosomal cap (head)
19. Cowper's gland (bulbourethral gland)
20. sperm cells (spermatazoa)

Suggested Activity #4: Identification of Diseases and Disorders of the Reproductive System

1. sterility
2. venereal
3. AIDS
4. salpingitis
5. gonorrhea
6. dysmenorrhea
7. pelvic inflammatory disease (P.I.D.)
8. abortion
9. cryptorchidism
10. syphilis

Suggested Activity #5: Research Paper

Evaluated by the instructor.

TEST / UNIT 9

The Reproductive System

I. Choose the word that matches the definitions from the list below.

breech presentation
cesarean section
copulation
embryo
episiotomy
genitalia

gestation
fertilization
fetus
hormone
hysterectomy
menarche

menopause
menstruation
ovulation
parturition
reproduction

semen
spermatazoon
vasectomy
zygote

1. process by which offspring are produced _______________ 1.
2. secretion of a ductless gland that regulates the function of other organs _______________ 2.
3. early or developing stage of any organism; in humans, the second through the eighth week of uterine life _______________ 3.
4. male reproductive cell _______________ 4.
5. union of an ovum with a sperm cell to produce a zygote _______________ 5.
6. secretion of male reproductive organs containing sperm cells and secretions from accessory reproductive glands _______________ 6.
7. removal of a segment of the vas deferens to produce sterility in males _______________ 7.
8. the beginning of menstruation _______________ 8.
9. periodic discharge of ovum from ovary _______________ 9.
10. surgical removal of the uterus _______________ 10.
11. the time that the embryo or fetus remains in the uterus _______________ 11.
12. cessation of menstruation _______________ 12.
13. removal of a fetus by means of incision into the uterus, usually by way of the abdominal wall _______________ 13.
14. sexual intercourse _______________ 14.
15. cell produced by the union of an ovum and sperm cell _______________ 15.

II. Identify the numbered parts of the diagram of the male reproductive system.

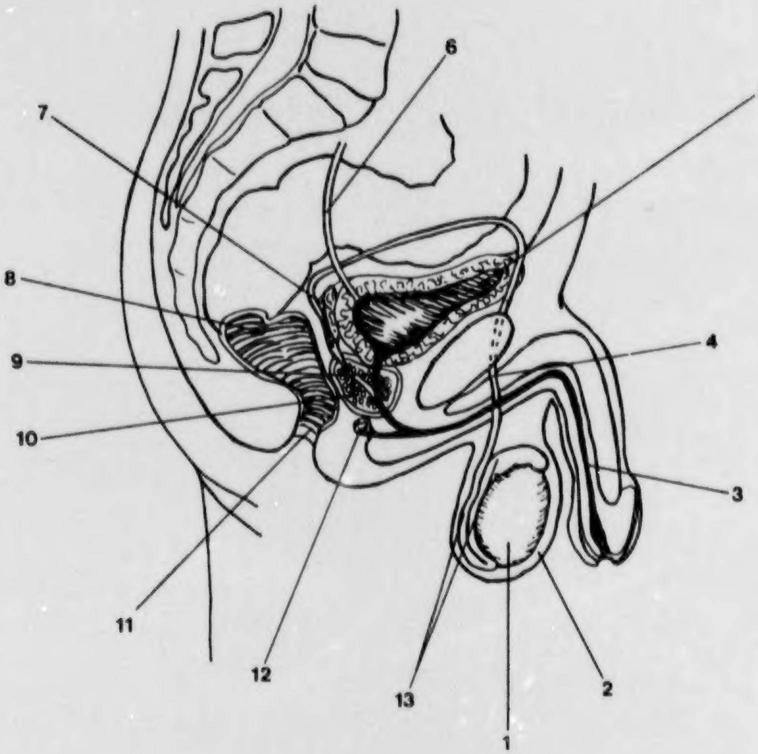
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________

III. Identify the numbered parts of the diagram of the female reproductive system.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________

IV. Tell whether each of the following hormones influences male or female development, or is lactogenic.

1. estrogen ____________________ 1.
2. progesterone ____________________ 2.
3. testosterone ____________________ 3.
4. follicle-stimulating hormone (FSH) ____________________ 4.
5. oxytocin ____________________ 5.
6. luteinizing hormone (LH) ____________________ 6.
7. prolactin ____________________ 7.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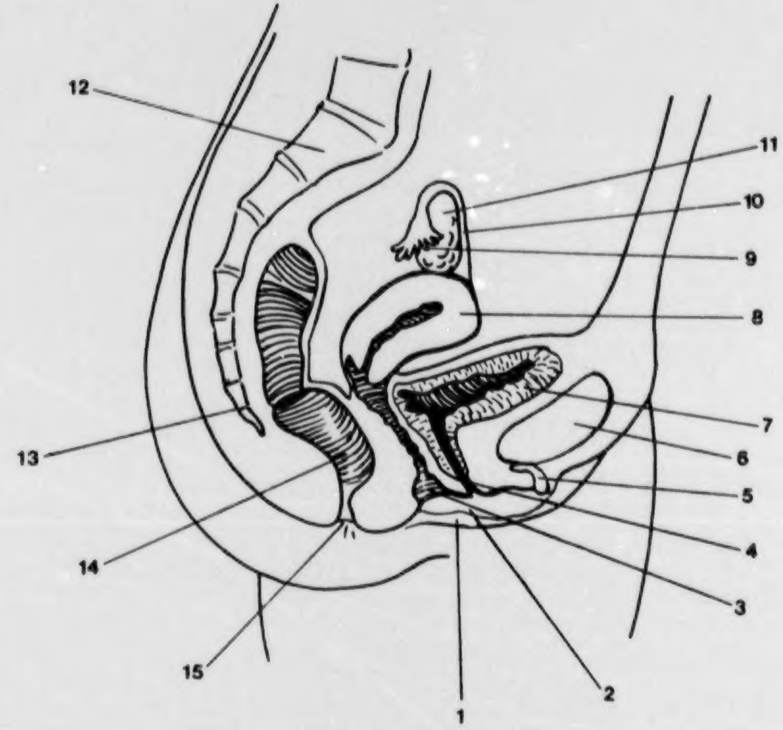
7
5
8
4
9
10
3
11
12
13
2
1


12
11
10
9
8
13
7
6
5
4
14
3
15
2
1

V. Name two functions of each of the following:

1. ovaries

   a. ____________________

   b. ____________________

2. oviducts

   a. ____________________

   b. ____________________

3. uterus

   a. ____________________

   b. ____________________

4. sperm cells

   a. ____________________

   b. ____________________

5. epididymis

   a. ____________________

   b. ____________________

VI. Complete the following statements.

1. The thin, yellowish fluid secreted by the mammary glands prior to milk production that contains maternal immune bodies, proteins, and calories is the ____________ 1.

2. Early in the menstrual cycle, the ovarian follicles begin to grow. On about the fourteenth day, one follicle ruptures and releases a(an) ____________ 2.

3. The inner layer or lining of the uterine wall is the ____________ 3.

4. The hormone secreted by the corpus luteum is ____________ 4.

5. A sudden feeling of warmth with sweating, headaches, and depression are possible side effects of ____________ 5.

6. A human pregnancy lasts ________________ weeks. ________________ 6.

7. The stage of embryonic development called a fetus is from ________________ 7.

VII. 1. Explain briefly the function of the placenta.

2. Why does cryptorchidism sometimes cause sterility?

3. Why are large numbers of sperm cells produced?

VIII. Match the following disorders or diseases with the descriptions. Use letter answers.

____ 1. an infectious disease transmitted primarily by sexual contact

____ 2. rupture of the abdominal wall in region where testes descend from abdomen to scrotum

____ 3. painful menstruation

____ 4. inability to reproduce (inability to form sperm cells or ova)

____ 5. inflammation of the testes; may be due to trauma, mumps, or other infection

____ 6. infectious venereal disease characterized by lesions which may involve any organ or tissue; caused by **Treponema pallidum**

____ 7. loss of embryo or fetus during the first 20 weeks of pregnancy

____ 8. any bacterial infection of uterus, ovaries, or oviducts

____ 9. venereal disease occurring most often in homosexual males; cause, cure, and treatment unknown, but patient's immune system does not function normally

____ 10. swelling or enlargement that may occur in any part of the reproductive system; common in breasts

a. abortion
b. cryptorchidism
c. dysmenorrhea
d. ectopic pregnancy
e. gonorrhea
f. genital herpes
g. inguinal hernia
h. orchitis
i. pelvic inflammatory disease
j. prostatitis
k. puerperal fever
l. salpingitis
m. sterility
n. syphilis
o. tumor
p. venereal disease
q. AIDS (acquired immune deficiency syndrome)

ANSWERS TO TEST

I.

1. reproduction
2. hormone
3. fetus
4. spermatazoon
5. fertilization
6. semen
7. vasectomy
8. menarche
9. ovulation
10. hysterectomy
11. gestation
12. menopause
13. cesarean section
14. copulation
15. zygote

II. Male

1. testis
2. scrotum
3. urethra
4. vas deferens
5. urinary bladder
6. ureter
7. seminal vesicle
8. rectum
9. ejaculatory duct
10. prostate
11. anus
12. bulbourethral (Cowper's) gland
13. epididymis

III. Female

1. labium major
2. labium minor
3. vagina
4. urethra
5. clitoris
6. pubic symphysis
7. urinary bladder
8. uterus
9. fimbriae
10. uterine tube (oviduct)
11. ovary
12. sacrum
13. coccyx
14. rectum
15. anus

IV.

1. female (lactogenic)
2. female (lactogenic)
3. male
4. female
5. female
6. lactogenic
7. lactogenic

V.

1. ovaries
    a. production of ova
    b. production of female hormones—estrogen and progesterone
2. oviducts
    a. provide a passageway for ovum from abdominal cavity near ovary to uterus
    b. provide site for fertilization of ovum
3. uterus (any two of these three)
    a. pregnancy
    b. labor
    c. menstruation
4. sperm cells
    a. to combine with ovum in fertilization
    b. to contribute genetic material to the zygote
5. epididymis (any two of these three)
    a. serves as a duct for sperm cells from testes to vas deferens
    b. stores sperm cells
    c. secretes a fraction of seminal fluid

VI.
1. colostrum
2. ovum (egg cell)
3. endometrium
4. progesterone
5. menopause
6. 40
7. the third month to birth

VII.
1. The placenta functions in the exchange of food, gases, and wastes between mother and baby. It also provides a barrier against bacteria.
2. The higher body temperature of the abdominal cavity (relative to that of the scrotum) inhibits sperm production.
3. Together the numerous sperm cells provide enough hyaluronidase to liquify the intercellular material that encases the ovum and makes penetration for fertilization possible.

VIII.
1. p
2. g
3. c
4. m
5. h
6. n
7. a
8. i
9. q
10. o

Unit 10

The Endocrine Glands

TEACHING OBJECTIVES

After students have covered the information in this unit, including the suggested activities, they should be able to—

1. define terms relating to the endocrine system;
2. distinguish between endocrine and exocrine glands;
3. name five general functions of hormones;
4. name the hormones secreted by the thyroid gland, and give the function of each;
5. locate the thyroid gland;
6. locate the parathyroid glands;
7. name the hormone produced by the parathyroid gland, and give its function;
8. describe the activity of glucagon and insulin;
9. locate the islands of Langerhans;
10. locate the pituitary gland;
11. list seven hormones secreted by the anterior pituitary, and give the function of each;
12. tell what is meant by the term "tropic" hormone;
13. list the hormones secreted by the posterior pituitary, and give their function;
14. locate the adrenal glands;
15. tell what hormones are produced by the medulla and by the cortex;
16. discuss the probable functions of the pineal body;
17. explain how the thymus gland differs from other endocrine glands;
18. give the function of the thymus gland;
19. list four gastrointestinal hormones;
20. name the function of androgens and estrogens; and
21. tell why prostaglandins are called "tissue hormones."

TEACHING SUGGESTIONS

Review Questions

The review questions are designed to emphasize important information and to help students organize the content. Class discussion centered on the questions may be helpful.

Suggested Activities

Suggested Activity #1: "Practice with New Terms"

This activity is designed to help students become familiar with the definitions included in the unit. They will need to read and study the list provided in order to complete the activity.

Suggested Activity #2: "Identification and Location of Endocrine Glands"

Study of the diagram will help students to locate the endocrine glands and to relate the location of one gland to others.

Suggested Activity #3: "Identification of Pituitary Hormones and Body Parts Affected"

The pituitary gland secretes so many hormones with unrelated functions that it is difficult for students to learn about them. This activity is designed to provide a means of acquainting students with these hormones and their functions.

Suggested Activity #4: "Practice with Names, Locations, Hormones, and Hormone Functions of the Endocrine Glands"

This activity provides further practice in identification of endocrine glands, their hormones, and their functions.

Suggested Activity #5: "Identification of Endocrine Glands, Hormones, and Their Functions"

This activity is designed to give students another opportunity to practice using information about the endocrine glands.

Suggested Activity #6: "Research Paper"

This exercise may be modified and presented as a project rather than a paper. The purpose is to provide opportunity for research, and for presentation of information.

Unit 10

Review Questions

1. Define **gland.**
2. What is the difference between exocrine and endocrine glands?
3. Define **hormone.**
4. What are five general functions of hormones?
5. Where is the thyroid gland located?
6. What is the principal function of the thyroid gland?
7. What is meant by **metabolic rate**?
8. What element is required by the thyroid gland to synthesize hormones?
9. What are the three hormones secreted by the thyroid gland?
10. What is the function of calcitonin?
11. How does the thyroid gland depend on the anterior pituitary?
12. What are procedures used to test thyroid function?
13. How does simple goiter affect the patient?
14. What is hypothyroidism in children called?
15. What is myxedema?
16. Describe symptoms of hyperthyroidism.
17. Where are the parathyroid glands located?
18. What is the function of parathormone (PTH)?
19. Name three body functions in which calcium is needed.
20. Locate the islands of Langerhans.
21. What is the effect of insulin on blood glucose? of glucagon?
22. Name three ways in which diabetes can be controlled.
23. What is the treatment for insulin shock?
24. Locate the pituitary gland.
25. What are the anterior and posterior lobes of the pituitary (hypophysis) called?
26. What is the result of an excess of somatotropin (GH), and of a deficiency?
27. Why could an excess of somatotropin (GH) result in diabetes?
28. What is acromegaly?
29. What are two functions of prolactin (PR)?
30. What anterior pituitary hormone stimulates the thyroid gland to produce thyroxine and triiodothyronine?
31. Which hormone controls the normal growth and development of the adrenal cortex?
32. What are the functions of the follicle-stimulating hormone (FSH) in females and in males?
33. Name the luteinizing hormones in males and in females.
34. What is the general function of LH and ICSH?
35. Which anterior pituitary hormone affects skin color?
36. Which posterior pituitary hormone is an antidiuretic?
37. What disease may result from a deficiency of vasopressin (ADH)?
38. What is the function of oxytocin?
39. List the hormones (tropic hormones) of the anterior pituitary that affect the activities of other endocrine glands.
40. Name the three hormones secreted by the adrenal cortex.
41. What is the function of the glucocortocoid hydrocortisone?
42. What anterior pituitary hormone stimulates the adrenal cortex to produce hydrocortisone?
43. What hormones are produced by the adrenal medulla?
44. What is the function of these hormones?
45. Where is the pineal body located?

46. What is the function of melatonin?
47. What is unusual about the thymus gland?
48. What are "T" cells?
49. Name four gastrointestinal hormones.
50. Define secondary sex characteristics.
51. What are the general terms for male sex hormones and for female sex hormones?
52. What are prostaglandins?

ANSWERS TO REVIEW QUESTIONS

1. a group of cells that produce a secretion
2. exocrine gland—liberates secretion by means of a duct
   endocrine gland—secretion is emptied directly into the blood or lymph; a ductless gland
3 secretions of the endocrine glands that regulate activities of body parts
4. (1) regulate metabolism or energy utilization
   (2) regulate body growth and development
   (3) regulate reproduction
   (4) regulate stress response
   (5) regulate cell permeability
5. in the neck in front of the trachea and below the larynx
6. to regulate the metabolic rate
7. the rate at which oxidation takes place in the cells with the release of energy
8. iodine
9. (1) thyroxine (tetraiodothyronine) (T_4)
   (2) triiodothyronine (T_3)
   (3) calcitonin (thyrocalcitonin)
10. to regulate and maintain a constant calcium level in the blood
11. Chemical sensors in the hypothalamus of the brain detect that the level of T_4 and T_3 are below normal or if the metabolic rate lowers, the anterior pituitary produces TSH. This, in turn, stimulates the thyroid gland to produce thyroxine.
12. determination of protein-bound iodine level, determination of basal metabolic rate, and use of radioactive iodine
13. In simple goiter, the body compensates for a lack of iodine by enlargement of the thyroid gland.
14. cretinism
15. hypothyroidism in adults
16. increased metabolic rate, increased appetite, weight loss, increased respiration, and protruding eyeballs (exophthalmia)
17. on the posterior side of the thyroid, one pair on each side
18. to regulate calcium metabolism and to maintain a constant calcium level
19. (1) clotting of blood
    (2) permeability of cell membranes
    (3) maintenance of normal neuromuscular irritability
20. specialized cells of the pancreas
21. Insulin decreases blood glucose by bringing about the conversion of glucose to glycogen. Glucagon controls the rate at which glycogen is converted into glucose.
22. (1) diet
    (2) oral drugs
    (3) injections of insulin
23. immediate administration of glucose
24. The pituitary is under the hypothalamus and attached to it. It lies in a depression in the sphenoid bone.
25. anterior—adenohypophysis
    posterior—neurohypophysis
26. An excess results in giantism, and a deficiency results in dwarfism.
27. It decreases catabolism of glucose; thus, an excess of somatotropin could result in an excess of glucose and even diabetes.
28. a disease of adults caused by an excess of somatotropin

29. (1) It stimulates the production of milk in mammary glands after delivery of a baby.
    (2) With luteinizing hormone, it helps maintain the corpus luteum in the premenstrual phase.
30. thyrotropin (thyroid-stimulating hormone) (TSH)
31. adrenocorticotropin (ACTH)
32. In females, it stimulates the development of egg cells to ovulation and the production of the hormone estrogen. In males, it stimulates the testes to produce sperm cells.
33. In males, the hormone is called interstitial-cell stimulating hormone or ICSH. In females. it is called luteinizing hormone or LH.
34. LH stimulates ovulation, the production of the corpus luteum, and prepares the uterus for implantation of the fertilized egg. LH stimulates the secretion of progesterone. ICSH stimulates the testes to develop and secrete testosterone.
35. melanocyte-stimulating hormone (MSH)
36. vasopressin (ADH)
37. diabetes insipidus
38. It stimulates the contraction of the smooth muscles of the uterus in childbearing and causes milk to be ejected into the mammary glands.
39. thyrotropin (TH), adrenocorticotropin (ACTH), follicle-stimulating hormone (FSH), and luteinizing hormone (interstitial-cell stimulating hormone)
40. (1) mineralocorticoids (aldosterone)
    (2) glucocorticoids (hydrocortisone, corticosterone, cortisone)
    (3) gonadocorticoids
41. causes amino acids to be converted to sugar instead of protein when there is a specific need
42. adrenocorticotropin (ACTH)
43. epinephrine (adrenaline) and norepinephrine
44. to help the body cope with stress
45. in the roof of the third ventricle of the brain behind the midbrain
46. In lower animals, it causes the skin to lose color and become pale.
47. It is conspicuous in infants, continues to grow until puberty, then atrophies.
48. lymphocytes that have gone to the thymus gland after development and are modified to destroy antigens of invading bacteria
49. gastrin, enterogastrone, secretin, and cholescystokinin
50. those characteristics that distinguish between males and females but are not directly concerned with reproduction
51. androgens (male) and estrogens (female)
52. They are a group of lipids (fatty acid derivatives) produced in almost all mammalian cells. They are called "tissue hormones" because they are secreted into the blood, are very active, and are thought to regulate hormone activity at the cellular or tissue level.

Suggested Activity #1: Practice with New Terms UNIT 10

Write the word defined or identified in each of the following phrases in the blank spaces. The words are listed below:

anabolism
diuretic
endocrine
endocrinology
exocrine
gland
hormone
lactation
lymphocyte
melanin
puberty
resorption
secondary sex characteristics
vestigial

1. the secretion of the endocrine glands ____________ 1.

2. an agent that causes an increase in the secretion of urine ____________ 2.

3. a small, incompletely developed organ or part; usually has no known function ____________ 3.

4. a group of cells that produce a secretion ____________ 4.

5. metabolic process in cells that results in the building of complex compounds ____________ 5.

6. pertaining to a ducted gland ____________ 6.

7. type of leukocyte formed in the lymph tissue ____________ 7.

8. the study of the endocrine glands ____________ 8.

9. the sex characteristics that are not directly concerned with reproduction ____________ 9.

10. one of a group of pigments responsible for skin and eye color ____________ 10.

11. pertaining to glands whose secretion empties directly into the blood or lymph; ductless glands ____________ 11.

12. period in life in which persons become capable of reproduction ____________ 12.

13. secretion of milk in the mammary glands ____________ 13.

14. to absorb again; to dissolve and assimilate ____________ 14.

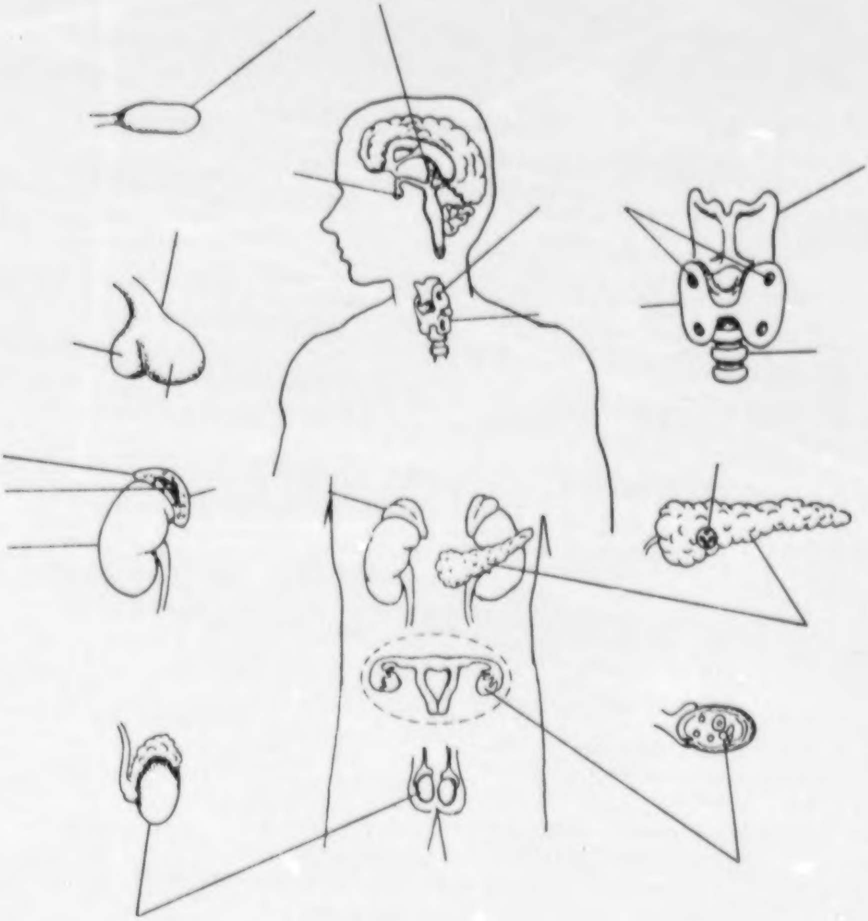
Suggested Activity #2: Identification and Location of Endocrine Glands UNIT 10

Objective: To locate and identify the endocrine glands

Materials:
Figure 3, diagram of endocrine glands
Unlabeled diagram of endocrine glands
Human torso model

Procedure:
1. Review the diagram of the endocrine glands shown in figure 3.
2. Locate and identify the various endocrine glands using the model of the human torso.

Results: Correctly label the diagram of the endocrine glands without using references.



Suggested Activity #3: Identification of Pituitary Hormones and Body Parts Affected **UNIT 10**

Objective: To reinforce an understanding of the role of the hormones of the pituitary gland in relation to other body organs and glands

Materials: Figure 4
Unlabeled diagram of structures influenced by various pituitary hormones

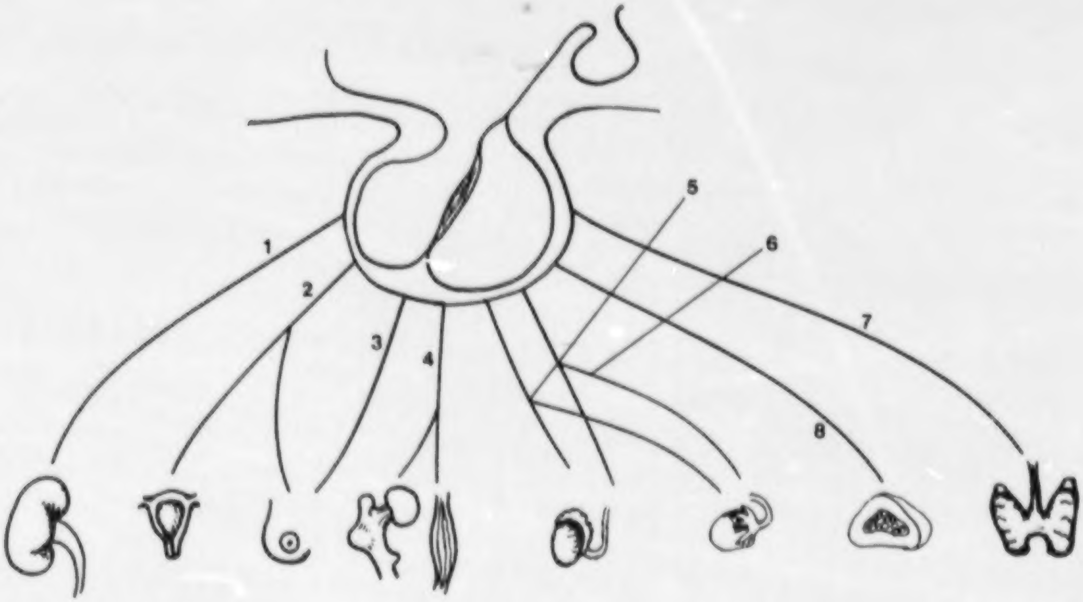
Procedure: Correctly identify the hormones that affect the following body organs or glands. Write the names of the numbered hormones in the blank spaces.

Posterior Pituitary

1. ______________________
2. ______________________

Anterior Pituitary

3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________



Suggested Activity #4: Practice with Names, Locations, Hormones, and Hormone Functions of Endocrine Glands

Objective: To become familiar with the location, hormones produced, and hormone functions of the various endocrine glands

Materials: Figure 7, "Endocrine Glands, Hormones, and Their Functions"

Procedure: Answer the following questions using figure 7.

1. Locate the thyroid gland.
2. What is the function of T_3 and T_4?
3. What hormone is produced by the parathyroids?
4. Locate the islands of Langerhans.
5. What is the function of insulin?
6. How does the function of glucagon differ from that of insulin?
7. What is another name for the anterior pituitary?
8. What is the function of somatotropin?
9. Which hormone secreted by the anterior pituitary stimulates milk secretion and breast development during and after pregnancy?
10. What hormones are produced as a result of stimulation by the thyroid-stimulating hormone (TSH) of the anterior pituitary?
11. Which other endocrine gland is controlled by the adrenocorticotropic hormone (ACTH) of the anterior pituitary?
12. What is the function of the follicle-stimulating hormone (FSH)?
13. Which hormone of the anterior pituitary stimulates the development of the testes and secretion of the testosterone?
14. What is the corresponding hormone in females?
15. What is the function of the melanocyte-stimulating hormone (MSH) of the anterior pituitary?
16. Which four hormones of the anterior pituitary regulate the activity of other endocrine glands? (These are called "tropic" hormones).
17. Name the two hormones secreted by the posterior pituitary.
18. Why is vasopressin called the antidiuretic hormone?
19. What is the function of the mineralocorticoids of the adrenal cortex?
20. What is the name of the group of hormones of the adrenal cortex to which hydrocortisone, corticosterone, and cortisone all belong?
21. Where is epinephrine (adrenaline) produced?
22. What is the function of norepinephrine?
23. Locate the pineal body.
24. What hormone is produced by the thymus gland?
25. What is its function?
26. Name four gastrointestinal hormones.
27. Which gastrointestinal hormone lessens gastric activity when fats are in the intestine?
28. What are two hormones secreted by the testes?
29. Locate the ovaries.
30. Give another function of the ovaries besides maintaining pregnancy, preparing for lactation, initiation of the menstrual cycle, and rhythmic changes in female reproductive cycle.

Suggested Activity #5: Identification of Endocrine Glands, Hormones, and Their Functions

Objective: To study the hormones secreted by the endocrine glands and their various functions

Materials: Figure 7, "Endocrine Glands, Hormones, and Their Functions"

Procedure:

1. Study figure 7 to review the names of the endocrine glands and to learn the names of their hormones and the functions of each.
2. Place the information indicated in each numbered blank on the chart of Endocrine Glands, Hormones, and Their Functions prepared especially for this activity, in the following numbered blanks.

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

(7) ____________________

(8) ____________________

(9) ____________________

(10) ____________________

(11) ____________________

(12) ____________________

(13) ____________________

(14) ____________________

(15) ____________________

(16) ____________________

(17) ____________________

(18) ____________________

(19) ____________________

(20) ____________________

ENDOCRINE GLANDS, HORMONES, AND THEIR FUNCTIONS

Gland	Location	Hormone	Primary Function
Thyroid	1	1. Thyroxine or Tetraiodothyronine (T_4)	2
		2. Triiodothyronine (T_3)	
		3. Calcitonin	Regulates calcium balance
Parathyroids	Posterior surface of the thyroid	3	Regulates calcium metabolism and maintains a constant calcium level
Islands of Langerhans	4	1. Insulin	Regulates rate of glucose metabolism. Regulates concentration of glucose in the blood. Converts glucose to glycogen
		2. Glucagon	Maintains glucose concentration by causing liver to convert glycogen to glucose
Pituitary (Hypophysis)	Base of the brain		
Anterior Pituitary (Adenohypophysis)		1. Growth hormone (GH) or Somatotropin (STH)	5
		2. 6	Stimulates milk secretion and breast development during and after pregnancy Helps maintain corpus luteum in premenstrual phase of cycle (with luteinizing hormone)
		3. Thyroid-stimulating hormone (TSH)	Stimulates the production of thyroxine and triiodothyronine
		4. Adrenocorticotropic hormone (ACTH)	7 Stimulates the production of cortex hormones (hydrocortisone and glucocorticoids)
		5. Follicle-stimulating hormone (FSH)	8
		6a. Luteinizing hormone (LH) (in females)	Stimulates ovulation, prepares uterus for implantation of fertilized egg Causes secretion of progesterone, which readies mammary glands for milk production
		9	Stimulates testes to develop and secrete testosterone
		7. Melanocyte-stimulating hormone (MSH)	10

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Gland	Location	Hormone	Primary Function
Posterior pituitary (Neurohypophysis)		1. 11	Decreases water loss
		2. 12	Promotes generalized contraction of smooth muscles, particularly the uterus in late pregnancy Causes milk to be ejected into mammary glands
Adrenals	Above each kidney		
Cortex		1. Mineralocorticoids, mainly aldosterone	Controls water and electrolyte balance, particularly sodium and potassium
		2. 13 hydrocortisone, corticosterone, and cortisone	Maintains normal metabolism Helps body to resist stress
Medulla		1. Epinephrine (Adrenaline)	Helps body to cope with emergency situations
		2. Norepinephrine	14
Pineal*	15	Melatonin (produced in some animals)	Affects color in some animals
Thymus	In chest behind sternum	Thymosin	16
Gastrointestinal	Gastrointestinal mucosa	1. Gastrin	Speeds up secretion of pepsin and HCl by digestive glands of stomach
		2. 17	Lessens gastric activity when fats are in the intestine
		3. Secretin	Neutralizes chyme and stimulates the production of bile and pancreatic juice
		4. Cholescystokinin	Enhances activity of pancreas and liver
Gonads			
Testes in males	Scrotum	1. 18 2. 19	These two hormones together stimulate development of male reproductive organs and male secondary sex characteristics
Ovaries in females	Abdominal cavity	Estrogens	Initiates menstrual cycle and rhythmic changes in female reproductive cycle Helps to maintain pregnancy, and prepares for lactation
			20

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* The pineal body is also thought to produce adrenoglomerulotropin, which stimulates the adrenal gland to produce aldosterone.

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Objective: To gain more information in a given area and to practice techniques of research and development of a scientific paper. The instructor should provide information regarding extent of research and guidelines for writing the paper.

Suggested topics are:

- Diseases Resulting from Endocrine Dysfunction
- Results of Current Research on the Thymus or Pineal Glands, or Prostaglandins
- Lives of Prominent Endocrinologists (e.g., Banting—insulin)
- Uses of Radioactive Isotopes in Endocrinology

Topics should reflect student interest. The topic could provide the student with information regarding a specific career.

ANSWERS TO SUGGESTED ACTIVITIES

Suggested Activity #1: Practice with New Terms

1. hormone
2. diuretic
3. vestigial
4. gland
5. anabolism
6. exocrine
7. lymphocyte
8. endocrinology
9. secondary sex characteristics
10. melanin
11. endocrine
12. puberty
13. lactation
14. resorb

Suggested Activity #2: Identification and Location of Endocrine Glands

Use figure 3 to evaluate student answers.

Suggested Activity #3: Identification of Pituitary Hormones and Body Parts Affected

Posterior

1. vasopressin (antidiuretic hormone or ADH)
2. oxytocin

Anterior

3. prolactin
4. somatotropic hormone (GH)
5. luteinizing hormone (LH); in males, interstitial-cell stimulating hormone (ICSH)
6. follicle-stimulating hormone (FSH)
7. thyroid-stimulating hormone (TSH)
8. adrenocorticotropic hormone (ACTH)

Suggested Activity #4: Practice with Names, Locations, Hormones and Hormone Functions of Endocrine Glands

1. in front of the trachea and below the larynx
2. regulates metabolic rate
3. parathormone
4. in the pancreas
5. regulates glucose metabolism
6. Insulin regulates the conversion of glucose to glycogen. Glucagon regulates the conversion of glycogen to glucose.
7. adenohypophysis
8. regulates skeletal and muscular growth
9. prolactin (PR) (lactogenic hormone)
10. thyroxine (T_4) (tetraiodothyronine) and T_3 (triiodothyronine)
11. adrenal cortex
12. stimulates the development of egg cells and the production of estrogens in females
13. interstitial-cell stimulating hormone (ICSH)
14. luteinizing hormone (LH)
15. regulates deposition of melanin in the skin
16. (1) thyroid-stimulating (TSH)
    (2) adrenocorticotropic (ACTH)
    (3) follicle-stimulating (FSH)

(4) luteinizing hormone (LH) in females, and interstitial-cell stimulating hormone (ICSH) in males

17. vasopressin and oxytocin
18. It decreases water loss.
19. controls water and electrolyte balance, particularly sodium and potassium
20. glucocorticoids
21. in the adrenal medulla
22. constriction of blood vessels to raise blood pressure in stress
23. in the brain
24. thymosin
25. development of the immune system
26. gastrin, enterogastrone, secretin, cholescystokinin
27. enterogastrone
28. testosterone and androsterone
29. in the abdominal cavity
30. development of female secondary sex characteristics

Suggested Activity #5: Identification of Endocrine Glands, Hormones, and Their Functions

1. tracheo-laryngeal region
2. regulates metabolism
3. parathormone (PTH)
4. pancreas
5. regulates skeletal and muscular growth
6. prolactin (PR) (lactogenic hormone)
7. controls normal growth and development of the adrenal cortex
8. stimulates development of egg cells and production of estrogens in females
9. interstitial-cell stimulating hormone (ICSH)
10. regulates deposition of melanin in the skin
11. vasopressin (antidiuretic hormone) (ADH)
12. oxytocin
13. glucocorticoids
14. constriction of blood vessels to raise blood pressure in stress
15. brain
16. development of immune system
17. enterogastrone
18. testosterone
19. androsterone
20. stimulates development of secondary sex characteristics

Suggested Activity #6: Research Paper

Evaluated by the instructor.

TEST / UNIT 10

The Endocrine Glands

I. Match the terms with the numbered phrases using letter answers.

_____ 1. to absorb again; to dissolve and assimilate

_____ 2. the secretions of the endocrine glands

_____ 3. period in life in which persons become capable of reproduction

_____ 4. an agent which increases the secretion of urine

_____ 5. a small, incompletely developed organ, usually has no known function

_____ 6. type of leukocyte formed in lymph tissue

_____ 7. metabolic process in cells that results in the building of complex compounds

_____ 8. pertaining to a ducted gland

_____ 9. secretion of milk in the mammary glands

_____ 10. pertaining to glands whose secretion empties directly into the blood or lymph; ductless glands

a. anabolism
b. diuretic
c. endocrine
d. exocrine
e. hormones
f. lactation
g. lymphocyte
h. melanin
i. puberty
j. resorption
k. vestigal

II. Complete the following statements:

1. The study of endocrine glands is _______________ 1.

2. The element required by the thyroid gland to synthesize hormones is _______________ 2.

3. Calcitonin regulates the metabolism of _______________ 3.

4. The use of radioactive iodine, testing for protein-bound iodine, and a basal metabolic rate determination are three procedures to test the activity of the _______________ 4.

5. The disease that may result from hypothyroidism in children is called _______________ 5.

6. A patient in insulin shock needs _______________ 6.

7. An excess of somatotropin could result in _______________ 7.

8. The hormone of the anterior pituitary that stimulates the thyroid gland to produce thyroxine and triiodothyronine (T_3) is ________ 8.

9. The disease that may result from a deficiency of vasopressin or ADH is ________ 9.

10. General types of hormones secreted by the cortex of the adrenal glands are glucocorticoids, gonadocorticoids, and ________ 10.

11. Two endocrine glands that atrophy in adults are the thymus and the ________ 11.

12. Sex characteristics that are not directly concerned with reproduction are called _____ sex characteristics. ________ 12.

13. Two hormones that prepare the body for action in stress are norepinephrine and ________ 13.

14. Lymphocytes that go to the thymus gland prior to assuming their place in lymphoid tissue are called ________ 14.

15. Tissue hormones or ______, produced in most cells, seem to regulate hormone activity at the tissue or cellular level. ________ 15.

III. Use short answers for the following questions.

1. Locate the thyroid gland.

________________________ 1.

2. What is the function of T_3 and T_4 (thyroxine)?

________________________ 2.

3. Which hormone of the anterior pituitary regulates the skeletal and muscular growth?

________________________ 3.

4. What disease may result from a lack of insulin?

________________________ 4.

5. Where is epinephrine (adrenaline) produced?

________________________ 5.

6. What is the function of the follicle-stimulating hormones (FSH)?

________________________ 6.

7. Name three gastrointestinal hormones.

____________________ 7.

____

____

8. What is the function of thymosin?

____________________ 8.

9. How are the activities of insulin and glucagon related?

____________________ 9.

10. Name three "tropic" hormones.

____________________ 10.

____

____

IV. List four general functions of hormones

1. ____
2. ____
3. ____
4. ____

ANSWERS TO TEST

I.

1. j	6. g
2. e	7. a
3. i	8. d
4. b	9. f
5. k	10. c

II.
1. endocrinology
2. iodine
3. calcium
4. thyroid gland
5. cretinism
6. glucose
7. giantism
8. thyroid-stimulating hormone (TSH)
9. diabetes insipidus
10. mineralocorticoids
11. pineal body
12. secondary
13. epinephrine (adrenaline)
14. "T" cells
15. prostaglandins

III.
1. tracheo-laryngeal region
2. regulates metabolic rate
3. somatotropin (GH)
4. diabetes mellitus
5. adrenal medulla
6. stimulates the development of egg cells and the production of estrogen
7. Any three: gastrin, enterogastrone, secretin, cholescystokinin
8. development of the immune system
9. Insulin regulates the conversion of glucose to glycogen. Glucagon regulates the conversion of glycogen to glucose.
10. Any three:
    (1) thyroid-stimulating hormone (TSH)
    (2) adrenocorticotropic hormone (ACTH)
    (3) follicle-stimulating hormone (FSH)
    (4) luteinizing hormone (LH)
    (5) interstitial-cell stimulating hormone (ICSH)

IV. Any four of these:
1. regulation of metabolism or energy utilization
2. regulation of body growth and development
3. regulation of reproduction
4. regulation of stress response
5. regulation of cell permeability

PROGRESS CHART

Applied Anatomy and Physiology

Specific Competencies

Directions: After the student has completed this package, the instructor should rate the student's job preparedness by completing the chart for the areas listed.

Rating Scale:

3—Skilled: Can perform with little or no supervision.
2—Partial Skill: Can perform but requires supervision.
1—Introduction: Introduced to occupational area.

Unit 1. The Organization and General Plan of the Body

	3	2	1
1. Define terms relating to the organization and general plan of the body.			
2. Identify studies related to anatomy and physiology.			
3. List and describe the levels of structural organization of the body.			
4. Define **anabolism** and **catabolism.**			
5. Name, locate, and give the function of cell parts.			
6. Describe special structures that modify cells for a specific role.			
7. Name four types of tissue, and give the general function of each.			
8. Give examples of organs.			
9. Name nine major systems of the body.			
10. Define directional terms used to locate body parts.			
11. Name the four quadrants of the abdominopelvic cavity.			
12. Name the nine regions of the abdominopelvic cavity when the area is divided.			
13. Locate the body cavities, and tell what organs are contained in each.			
14. Name and locate three body planes.			

Unit 2. The Skeletal System

1. Define terms relating to the skeletal system.			
2. Give the functions of the skeletal system.			
3. Describe two types of bone.			
4. Name, locate, and give the function of each part of a long bone.			
5. Give the materials required for building bone.			
6. Describe the different types of bones.			
7. Identify bones in the axial and appendicular skeletons.			
8. Identify specific bones on a model or diagram.			
9. Tell about the role of cartilage in the skeletal system.			

	3	2	1
10. Name and describe five types of bone fractures.			
11. Describe six types of joints.			
12. Explain types of movement at joints.			
13. Describe common bone diseases.			

Unit 3. The Muscular System

1. Define terms relating to the muscular system.			
2. List three functions of muscles.			
3. List three types of muscle.			
4. Give the general structure of a skeletal muscle.			
5. List the parts of a muscle cell.			
6. Explain how a muscle contracts.			
7. Discuss energy release in skeletal muscles.			
8. Explain "oxygen debt."			
9. Explain the origin and insertion of skeletal muscles.			
10. Give ways in which muscles are named.			
11. Identify several muscles from a diagram, chart, or model.			
12. Identify common disorders of muscles.			
13. Demonstrate three sites for intramuscular injection.			
14. Tell what drug implantation means.			

Unit 4. The Digestive System

1. Define terms relating to the digestive system.			
2. Name and locate the parts of the digestive system.			
3. Name four types of teeth, and give the function and number of each kind.			
4. Discuss digestion in the stomach.			
5. Name the regions of the small intestine.			
6. Tell how the small intenstine is modified to increase its absorption surface.			
7. Name digestive juices, and give the source and action of each.			
8. Discuss the function of the large intestine.			
9. Give the nondigestive functions of the liver.			
10. Explain the digestive role of the pancreas.			
11. Identify the omentum, peritoneum, and mesentery.			
12. Identify disorders of the parts of the digestive tract.			

Unit 5. The Blood and Cardiovascular System

1. Define terms relating to the cardiovascular system.			
2. Discuss the functions of blood.			
3. Describe and give the function of the formed elements of blood.			
4. Give the role of platelets in the coagulation of blood.			
5. Discuss the significance of ABO blood types.			
6. Tell why the Rh factor is important in some pregnancies and transfusions.			
7. Describe the structure of the heart.			
8. Trace the course of the blood through the heart.			
9. Discuss the conduction system of the heart.			
10. Define pulse and blood pressure.			
11. Name the types of blood vessels.			
12. Describe the two major circuits formed by the blood vessels.			
13. Name and give the function of the components of the lymph system.			
14. Identify common diseases of the blood and cardiovascular system.			

Unit 6. The Respiratory System

3 2 1

1. Define terms relating to the respiratory system.
2. Distinguish among breathing (pulmonary ventilation) and external and internal respiration.
3. Identify the parts of the respiratory system, and give the function of each.
4. Trace the pathway of inspired and expired air through the respiratory system.
5. Locate the parts of the respiratory system on a diagram.
6. Locate and give the functions of the sinuses.
7. Name the seven openings into the pharynx.
8. Tell how sound is produced by the vocal cords.
9. Describe the Heimlich maneuver.
10. Explain how air is caused to flow in and out of the lungs.
11. Identify types of breathing.
12. Explain the movement of gases between alveolar walls and the blood.
13. Tell how oxygen and carbon dioxide are transported in the blood.
14. Explain how breathing is controlled by the nervous system and chemical stimulation.
15. Describe cardiopulmonary resuscitation.
16. Identify common diseases of the respiratory system.

Unit 7. The Nervous System and Special Senses

1. Define terms relating to the nervous system and special senses.
2. Identify the main parts of the nervous system.
3. Locate and give the functions of the parts of the brain.
4. Explain the importance of a constant oxygen supply to the brain.
5. Tell how the meninges and cerebrospinal fluid protect the brain.
6. Locate the spinal cord.
7. Give the function of cranial and spinal nerves.
8. Describe the autonomic nervous system.
9. Tell the function of each part of a neuron, and of three types of neurons.
10. List types of neuroglia.
11. Describe the pathway of stimulus to response
12. Describe a reflex arc.
13. Name and locate the major parts of the ear.
14. List the parts of the ear concerned with balance and
15. Trace the pathway of auditory stimulation to the brain.
16. Name and locate the major parts of the eye.
17. List accessory parts of the eye.
18. Identify common errors in vision.
19. Discuss the perception of odors.
20. Tell why pain is a protective sense.
21. Identify common diseases and disorders of the nervous system and special senses.

Unit 8. The Urinary System

3 2 1

1. Define terms relating to the urinary system
2. Identify the parts of the urinary system.
3. Give the function of each part of the urinary system.
4. Give the steps in the formation of urine.
5. List the characteristics of urine.
6. Discuss dialysis and transplants.
7. Identify diseases and disorders of the urinary system.

Unit 9. The Reproductive System

1. Define terms relating to the reproductive system.
2. Identify parts of the male and female reproductive systems.
3. Give the functions of the reproductive parts.
4. List hormones that control activities of the reproductive organs.
5. Review the sequence of events in menstruation.
6. Define **menarche** and **menopause.**
7. Discuss lactation.
8. Identify secondary sex characteristics.
9. Discuss fertilization and major events in embryonic development.
10. Recognize descriptions of diseases and disorders of the reproductive system.

Unit 10. The Endocrine Glands

1. Define terms relating to the endocrine system.
2. Distinguish between endocrine and exocrine glands.
3. Name five general functions of hormones.
4. Name the hormones secreted by the thyroid gland, and
5. Locate the thyroid gland.
6. Locate the parathyroid gland.
7. Name the hormone produced by the parathyroid gland, and give its function.
8. Describe the activity of glucagon and insulin.
9. Locate the islands of Langerhans.
10. Locate the pituitary gland.
11. List seven hormones secreted by the anterior pituitary, and give the function of each.
12. Tell what is meant by the term "tropic" hormone.
13. List the hormones secreted by the posterior pituitary, and give their functions.
14. Locate the adrenal glands.
15. Tell what hormones are produced by the medulla and by the cortex.
16. Discuss the probable functions of the pineal body.
17. Explain how the thymus gland differs from other endocrine glands.
18. Give the function of the thymus gland.
19. List four gastrointestinal hormones.
20. Name the function of androgens and estrogens.
21. Tell why prostaglandins are called "tissue hormones."

(Instructor's Signature)

(Student's Name)